THE LEHIGH QUARTERLY.

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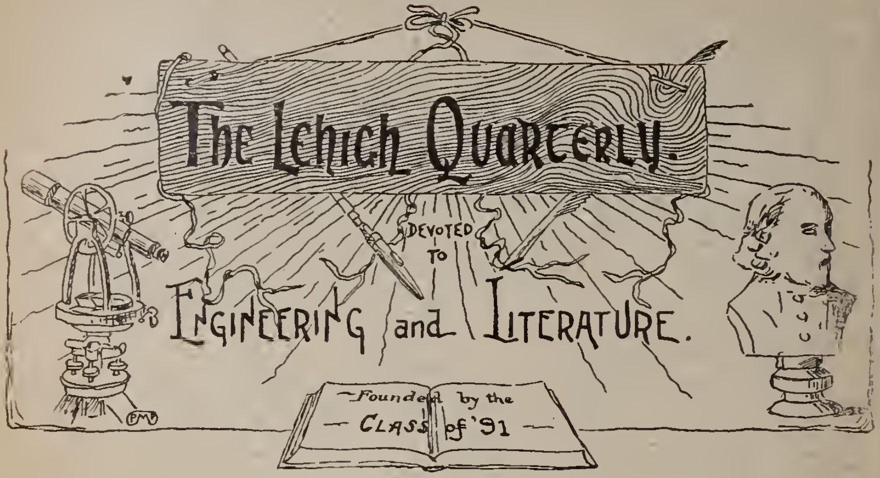
THE LEHIGH UNIVERSITY,

South Bethlehem, Pa.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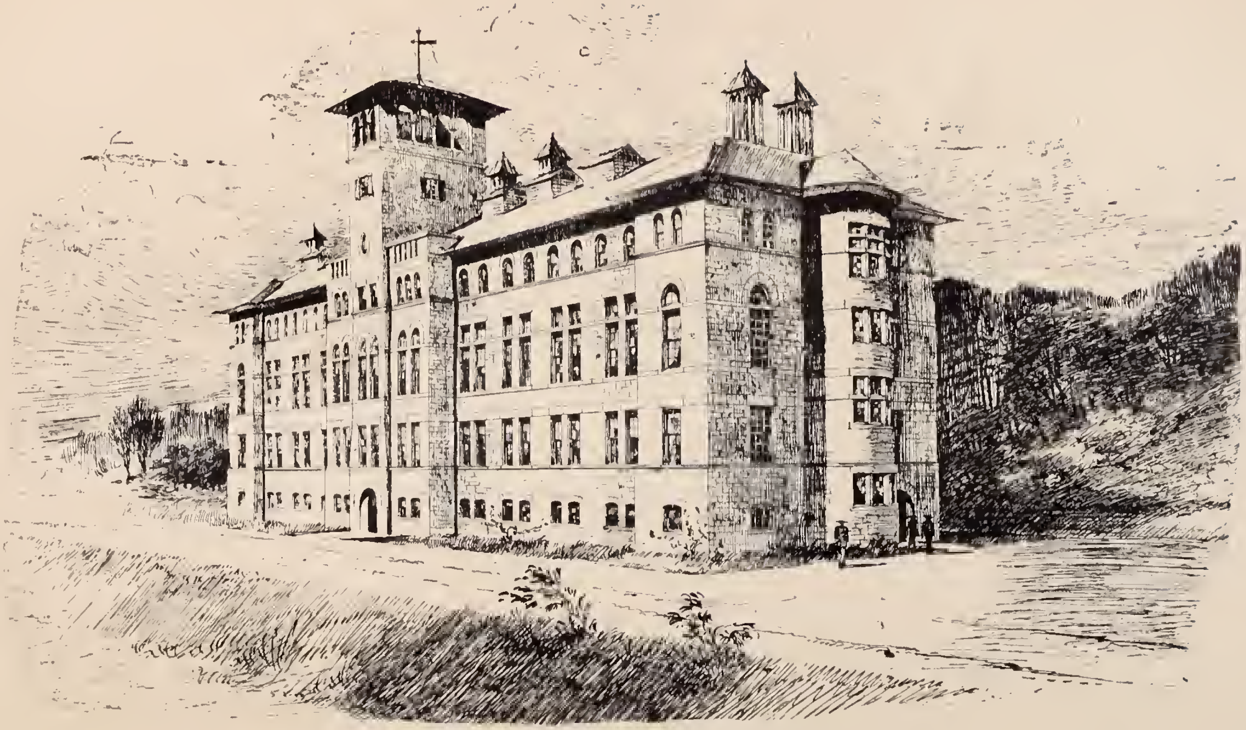

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THE

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Vol. III. FEBRUARY, 1893. No. 1.

THE LIFE OF INCANDESCENT LAMPS.

BY ELIHU THOMSON.

In the present paper the writer intends to discuss briefly some of the conditions affecting the life of an incandescent lamp. It is, as yet, by no means agreed upon just what period shall be taken as representing such life. Formerly the life of a lamp was taken as the period of time the lamp could be used at normal voltage until the rupture of the filament. At the present time, however, there is a tendency to call the life-period the time during which the lamp used at normal voltage will give a luminous effect or efficiency, within a certain per cent. of its original effect when new.

According to this view a lamp will be "dead" when it is yielding light at too low efficiency, owing to deterioration of the carbon of the filament and blackening of the glass.

The question here presents itself, can a filament be made which will not deteriorate, and therefore not blacken the interior of the bulb? The writer is inclined to say no to this, if we are required to adhere to carbon, and carbon as yet seems to be the best material in existence. It is so on account of its infusibility, and apparent non-volatility. It actually does soften at extremely high temperatures, and will bend readily when so softened. It does not, however, melt at the highest known temperatures. While apparently non-volatile it does readily vaporize or evaporate from the solid state at the temperature of the positive crater of an arc lamp. In fact, the temperature of such crater can not rise beyond the vaporization point from the carbon because the carbon would vaporize at once and limit the increase.

It is very probable that carbon, infusible as it seems, could be fused at arc temperatures while under pressure. Thus an electric arc in an inert gas at high pressure would probably drip melted carbon, which on solidification would form graphite in masses or crystals. Now, it is found that the nearer we approach the arc temperature in the running of incandescent lamps, the less the life of the filament, the bulb being more readily blackened. Experience has shown also, that even with the most perfect filaments the temperature must be limited to that which corresponds to a consumption of energy of from 3 to 4 watts per candle, in order that the lamps shall have a life which shall enable them to be used with an economy of cost for replacements commensurate with the cost of energy or power to work the lamps.

The deterioration of an incandescent lamp has often been laid to bombardment of gas molecules set in motion either by the heat or by electric discharges, from one leg of the filament to the other, through the gaseous space, but the writer has long been convinced that in a well exhausted lamp it is due almost entirely to evaporation by high temperature. Just as ice, near its melting point, and even far below that, evaporates in vacua and even in dry air, so carbon, practically fixed at low temperatures, acquires in vacua a certain volatility at an increasing rate with the temperature. The sublimed carbon is deposited on the sides of the containing bulb and forms what has been called the "age coating." This age coating may become so thick as to obscure or absorb a large percentage of the light evolved by the incandescent filament and convert it into low heat. Manifestly the age coating will grow more rapidly with the volatility of the carbon, which at the start depends, other things equal, on the temperature or efficiency of light conversion. A lamp using two watts per candle may be expected to blacken its bulb and reduce its filament by loss of evaporated carbon much more rapidly than one using four watts per candle. A thick and short filament, where the surface in proportion to bulk is smaller than in a long, thin, delicate filament, may be expected to deteriorate less rapidly if worked at a given efficiency.

Hence, where attempts to produce lamps to work with 200 or more volts have been made it has generally been found that on account of the extreme fineness and length of the carbon filament demanded, the life has been unsatisfactory unless the efficiency of light conversion were sacrificed. Manifestly then, unless the structure of the filament throughout its length be uniform, and its cross section uniform, or at least, if varying at all, varying in accordance with the facility of heat radiation of different parts of the length, there will be some parts of the carbon hotter than others. If there are cracks or fissures in the carbon the passage of current will not be over a uniform resistance and parts will be much hotter than others. These differences would be undistinguishable by the eye, but would readily account for the differences to be noted in pure carbon filaments of various manufacture or from various materials carbonized. Again, the radiation is from the outer surface of a filament only, while the production of heat is throughout its section. Hence, if uniform conduction of current exists in the section of the carbon the interior thereof may be much hotter than the visible exterior. This particularly applies to the case of thick filaments, short or long. Carbon is not such a good conductor of heat that the heat from the interior is instantly delivered to the surface for radiation. Unless the conductivity of the carbon for current be better on the exterior surface than in the interior, with all filaments, and particularly with thick ones, uneven heating, uneven expansion, (tending to fissures) and undue evaporation from interior portions, may take place.

The application of the hydro-carbon treatment serves the very useful purpose of making the conductivity of the outer layer superior to that of the inner layers, and so causes the current to flow mostly by the surface from which the radiation takes place. This tends to uniformity of temperature. Lack of uniformity of temperature due to bad structure, as above pointed out, means a lamp which is less efficient for a given life, or has less life for a given efficiency. Perfect structure means perfect uniformity of temperature, and hence the lowest evaporation consistent with the temperature. Purity of carbon tends to the same result necessarily.

Now let us assume a lamp lighted by current, and study what occurs. Any overheated spot or particle of carbon in the filament yields more carbon vapor than other portions, thus increasing the resistance locally at that spot and making the effect worse as time goes by. Besides this, a continued slow evaporation proceeds over all parts of the surface of the filament. But manifestly, for the carbon to remain vaporous in a vacuum demands that the vapor shall be maintained at the high temperature at which it was evolved. On leaving the surface of the filament, however, and passing into the vacuous space, it is immediately cooled and condenses as a fine soot just at the surface of the filament, which soot is propelled by the radiation and continual evolution of more vapor almost in straight lines to the interior surface of the bulb and there adheres. If anything be in the way the particles are stopped and a clear shadow is formed on the bulb. Hence a sooted lamp often shows a clear shadow of each leg of the filament which has stopped the radiating soot from the other. This action soon soots up the surface of the filament and blackens it, again conducing to the loss of efficiency and lack of uniformity of radiation and temperature.

As in a given time of burning a certain evaporation takes place, not depending on the size of the vacuum chamber, it would follow that the effects of the "age coating" itself in diminishing the light-giving power of a lamp will be much less as the *enclosing bulb is greater in size*, for the same deposition will yield a much thinner coat of absorbent carbon particles over a large or extended surface than over a small one. It is conceivable that a glass envelope could be made to cover a filament so closely as to have but a small surface to receive the deposit, and to be rendered opaque with a total amount of deposit, which would only slightly darken a large bulb.

It follows from the above also that the greatest possible uniformity of temperature of the carbon filament is demanded in order that what evaporation must and does take place shall not deform or render irregular the conduction of current in the filament. It must be remarked here that it is, of course, admitted that the presence of certain gases or vapors may, in some cases, have the power of assisting the evaporation or carriage of carbon from the filament to the bulb, but it will need extended research to prove or disprove this, and to discover and classify such deleterious gases, and the amounts which may be expected to do harm.

It appears to be true that one limit of practical improvement in efficiency in the incandescent lamp is to be found in the properties of the element carbon, and particularly its volatility. We do not yet know whether any other conducting substance is to be found which is less volatile at such high temperatures. It is fairly safe to say that none has yet been found and that carbon, as pure and perfect in structure as possible, is likely to hold its place at least for some time to come as the material for incandescent lamp filaments, as carbon has held its place for arc pencils. It is indeed somewhat striking that carbon in flames and existing therein as fine solid particles has furnished the chief artificial illumination of the past, to be succeeded by strips of carbon in incandescent lamps and solid pencils in arc lighting of the present and future. In each case its property of being but slightly volatile, even at very high temperatures, has enabled it to serve its purpose.

THE LELAND STANFORD, JUNIOR, UNIVERSITY.

In 1885 it was announced to the public that Senator and Mrs. Leland Stanford proposed to found a university in memory of their son, an only child, who had died a short time before. The idea came from the boy, and had he lived, it was his wish that his parents should devote a part of their great estate to the founding of a university. His death only hastened the carrying out of his wishes. From their announcement in 1885, Mr. and Mrs. Stanford entered into the plans with their whole heart and gave them their best energies. They desired to found a non-sectarian university in which all persons without regard to race or sex should have equal opportunities; a university to be absolutely free to all classes: they have accomplished their purpose.

Buildings were at once begun upon their Palo Alto farm, and from that day to this the sound of the workman's hammer has not ceased at Palo Alto. More than three million dollars have been spent in buildings, as much more will not complete the plans that have been adopted. But buildings are not erected faster than they are needed, and the plans allow for a large growth, so that they will not be completed for some years.

One who could paint vivid word pictures could give a very interesting account of our buildings and grounds, but it is carrying coal to New Castle to describe beautiful university buildings and grounds to Lehigh men, who have before their eyes examples of these that are second to none. It is rather the work and organization of the university than its equipment of which I wish to speak.

In the spring of 1891 the buildings were so far advanced that it seemed advisable to open the university to students the following fall. The founders very wisely decided to select a president and leave all educational matters to be settled by him. Hence upon their choice very much depended and they fully realized this. David Starr Jordan, at that time president of the University of Indiana, was finally chosen as the man to organize the new university. Time will more and more confirm the wisdom of their choice. President Jordan was left entirely unhampered to gather his faculty around him. It was his idea that the work in the university should be largely elective, and upon this point most of the faculty agreed with him; as a result, nowhere, unless it be at Harvard, is the student so free to select his own studies as here. Indeed within certain limits this choice extends even to the entrance examinations. The question as to just how far the student is capable of selecting his own work advisedly is still an open one, and it permits of a great deal being said on both sides. On account of the importance of this question to all persons interested in educational matters, it seems probable that a few words as to the practical workings and the results obtained here, where the elective system is allowed in its fullest sense, would not be without interest to the readers of the QUARTERLY.

Entrance examinations are held in the following subjects: 1. English; 2, 3. Elementary Algebra; 4. Plane Geometry; 5.

Solid Geometry and Trigonometry; 6. Advanced Algebra; 7. Physics; 8. Chemistry; 9. Physiology; 10. Botany; 11. Zoölogy; 12. Freehand Drawing; 13. American History; 14. English History; 15. Grecian and Roman History; 16. English Literature; 17. Spanish; 18, 19. French; 20, 21. German; 22, 23. Latin; 24. Latin; 25, 26. Greek. The number of these subjects will undoubtedly be increased in the future.

A student may be admitted to the University in full standing by passing a satisfactory examination in any ten of these subjects, the only restriction in choice being that English must be one of the ten. Each number corresponds to a full year's work in the high school. Thus, for example, a man may offer five subjects in mathematics, and need to pass but five other examinations in addition to his English; or, if he has studied Latin three years, he may offer three subjects in Latin, or he may enter the University in full standing without any mathematics or any language but English.

Having entered the University the student is at liberty to choose his work where he will among the following departments: Greek, Latin, Germanic Languages, Romance Languages, English Language and Literature, Philosophy, Education, History, Economics, Mathematics, Astronomy, Physics, Chemistry, Botany, Entomology, Horticulture, Physiology and Histology, Zoölogy, Geology, Drawing, Civil Engineering, Mechanical Engineering, Mining Engineering, Physical Training and Hygiene, Military Science and Tactics.

The only requirements are that he shall select the work of some one department as his *major* subject, and complete the work in that department to the satisfaction of the professor in charge of that department before he shall receive his degree. But this department can not demand of any student more than one-third of his entire time; the other two-thirds the student is at liberty to fill with such studies as he may choose. This one-third time limit does not apply to the engineering courses, as the amount of work laid down in these courses requires the majority of the student's time for five years.

The professor in charge of the major subject which a student may select becomes that student's adviser, so to speak; he helps him to select the studies that will be most useful to him in the work he has chosen, provided he seeks such help, and counsels with him in regard to his work at any time. Every student is expected to take fifteen hours of work per week, three hours of laboratory or field work, counting as one of lecture or recitation; he is not permitted to take less than twelve hours per week nor more than eighteen hours without the special permission of the professor in charge of his major subject. When a student has satisfactorily completed courses equivalent to fifteen hours per week for four years of two terms each, or one hundred and twenty hours work in all, he is entitled to the degree of A.B. The engineering students are given their special degree in addition after completing one year of graduate work.

A student may change his major subject at any time by getting the permission of the professor whose work he wishes to drop, and the one whose work he wishes to take up.

Students who are at least 20 years old who, from any cause, do not wish to take the entrance examinations or can not enter upon certificate, may be admitted as special students upon the recommendation of the professor in whose deparment they wish to work. The professor may test the students ability to do the work of his department by examination or in any other way he sees fit. If at any time such special student fails in his work his connection with the University ceases.

At the close of the term, the reports are sent to the Registrar. Students are not ranked in any way, but are reported as *passed*, *conditioned*, or *failed*, as the case may be, failed meaning that the work has been so poor that the student must withdraw from the class. These are the only reports that are made. There is no system of absences and excuses, it is purely optional with each instructor whether he shall make any record of absences or not. If at any time a student from absence, or any other cause, fails to do the work of any instructor to the satisfaction of that instructor, he is dropped from the class. A student thus dropped from a class must show cause why he should not be dropped from the University.

There are no classes, freshmen, sophomore, etc., officially recognized, although the students classify themselves in this way for their own purposes of organization. But as scarcely any two students are doing exactly the same work throughout, it happens that in any recitation there may be representatives of all four of the college classes. Any student who expects to have one hundred and twenty hours work to his credit at the end of any term, becomes, about a month before the end of the term, *a candidate for a degree*; he is then referred to a committee on graduation. This committee examines his record, and if it is satisfactory the student is awarded his degree upon the satisfactory completion of the term's work; it matters not at the end of which term the work is completed, although the public commencement exercises are held only in May.

The work of the Faculty as a body is done almost entirely through committees, of three members each. A meeting of the whole Faculty is a very rare occurrence. The more important committees, and their work are: The Committee on Students' Affairs, having charge of any cases of discipline that may arise; Committee on Doubtful Cases, to whom students falling behind in their work are reported; Committee on Petitions, who consider all communications from the students; Committee on Graduation, who examine into the records of the candidates for degrees; Committee on Admission of Students, who look into the credentials of students who are admitted on certificate; Committee on Athletics, Committee on Publications, and many others. Any questions that would naturally come before the Faculty is referred at once by the President or Registrar to the proper committee and the point is settled without the invariable vexatious delays and waste of time that always comes from bringing questions before large bodies, to say nothing of the great saving of time to each professor in that only a small fraction of the questions need take his attention.

In this brief outline I have given enough to show the spirit of the organization of the University; it is the spirit of freedom, and there is a desire to avoid forms and technicalities. There are no more restrictions than seem absolutely necessary.

Every student who comes here is encouraged and assisted in selecting those studies for which he has a special aptitude, and then good work is expected from him, and in case good work is not done, it becomes very difficult for the student to explain why he is not doing good work, and at the same time give reasons why he should remain at the University.

To some who are used to the more detailed and restricted regulations of the older universities there will appear, no doubt, a looseness of organization that is dangerous, and I will confess that I had the feeling that many restrictions would necessarily be added as we gathered experience. After a trial of one year and a half these fears have completely disappeared, for, as a result of this system, there is collected at Palo Alto a body of students who are not excelled in enthusiasm, ability, and application to work by any body of students that I have ever known.

In a general education, good, conscientious work in any class of subjects, be they classical or scientific, historical or mathematical, will give a man the mental training and the habits that will help him in all the affairs of life. It matters little whether the actual facts that he learns are going to be of use to him or not; if the previous training has been good the man will easily adjust himself to his environments, and the facts will follow quickly enough where they are needed.

On the other hand, work poorly done in any subject is not only of no value, but it does positive harm. The student, while allowing himself to slight a subject through lack of interest, perhaps, is forming the dangerous habit of doing poor work which it will become more and more difficult for him to throw off as he grows older; a habit which, unless overcome, will most effectually close to him all avenues to success.

Any change in our college curriculum, by means of which it will be rendered less difficult for the student to acquire this indispensable habit of industry, must be a change for the better. One step in this direction, it seems to me, is to allow the student large liberty of choice in his work; this choice once made, insist upon his doing good work.

If there is a weak spot in the courses offered, if any instructor is willing to accept poor work, he will get it; the idle and shiftless students will be attracted to that course in which the work can be slighted—trust them to find such a course. The remedy is, however, not to limit the choice of the student, but to strengthen the weak course. No university can afford to support such courses, least of all those universities where the work is elective. GEO. M. RICHARDSON, '86.

Palo Alto, Cal., January 14, 1893.

THE LIMITING DISTANCE OF THE TRANSMISSION OF SPEECH BY THE TELEPHONE.

BY PAUL D. HONEYMAN, '91.

The problem of the propagation of electrical impulses in a conductor possessing both capacity and resistance, was first treated of by Sir William Thomson in a paper read before the Royal Society, in 1854, on 'The Speed of Signaling.' He has been followed by Preece, Blakesly, Joubert, and others, who have evolved more or less complex expressions for the laws governing the transmission of alternating impulses of varying periodicity. These expressions however are found to be of doubtful utility in practice, and when self induction is introduced, become useless. Knowledge of the limit of long distance telephoning leads to a thorough understanding of the relations of capacity, self-induction, and resistance in a conductor.

The composite tones of the voice on a theoretical line of no capacity and resistance can be said to be reproduced with absolute accuracy. The solid back transmitter and the Bell receiver as they exist today, when used under proper conditions, are near enough to perfection, and it is not to them that the telephone engineer looks for the solution of his greatest problems, but to the *line*.

The varying electro-motive force created in a conductor by the voice is itself composite, there being corresponding fundamentals and harmonics. Upon the number and intensity of the overtones accompanying the primary tones depends the character and quality of the sound transmitted. Capacity is first manifested by its action on the more delicate overtones, which are destroyed by a literal absorption in a manner analogous to the absorption of the impulses of air by a rubber bag, the stream of air issuing therefrom being uniform, though the simultaneous charging process is periodic. All such harmonics would suffer greatly in their transmission, and at the end of a long wire would be received in a greater or less state of degradation, depending on the pitch. If all the tones were reduced in strength in the same proportion, a relay could be employed to restore the various currents to their original intensity. The sympathetic power of the ear comes in here. The ear is a most excellent analyzer, and is continually discriminating between two or more contemporaneous and superimposed sounds, but, for the process of recomposition before a degraded composite tone can be truly interpreted, something more than the power of analysis is necessary. This the ordinary ear does not possess. If the effect of capacity was merely that of changing the relations of the parts, the ear would discriminate and restore, but it cannot create.

Self-induction on the other hand tends to counteract the effect of capacity. The waves of higher frequency travel the faster and the components of a composite tone constantly change their relative phases. This effect is modified by self-induction which causes a back electromotive force proportioned to the rate of change. Two waves of different periods therefore will be propagated more slowly, but with less difference in their rates, than with no self-induction; and the overcrowding and confusion due to a capacity effect is counteracted to some extent. A minimum of self-induction, however, is present in a straightaway copper wire, and it has in fact been entirely neglected by Preece in his well-known formulæ for the possibilities of the transmission of speech. He has shown that, neglecting self-induction, the limit of speech is expressed by the equation, capacity and resistance (K. R.)=a constant, and has fixed empirically the value of the constant to be 15,000 for overhead copper wire. When $KR=$ 10,000, speech becomes good, when KR is less than 10,000 the transmission is excellent. Fortunately practice has shown his values for the constant, at least, if not his whole fabric, to be at fault. The KR of the long distance line recently opened between New York and Chicago is about 32,000, and speech is excellent. The softest whisper and the most delicate intonation of the voice are distinctly recognized, and the volume is well sustained. The

Chicago line was not a carefully worked out mathematical triumph, it was rather an experimental triumph. The projectors were unable to decide for a long time as to the proper size of wire, and that used—number eight Birmingham wire gauge—was a compromise. The practicability of the line was ascertained by connecting up a number of trunk wires to Boston, till the required length was obtained. It is a lamentable circumstance that the science of telephony is yet in such a state that it is impossible to say with mathematical accuracy, that for the best transmission of speech a certain size of wire should be used for a given distance, and that the possibilities of long distance talking can not be defined in terms of the cost of copper or in actual miles.

To the question "Is it possible to talk across the continent?" the answer must be given, "It is impossible at present to tell." Recent achievements would seem to show that such a thing may be done. The American Telephone and Telegraph Company are rapidly extending their wires beyond Chicago. Conversation has already been held between Boston and Milwaukee. Additional wires will be strung to Chicago, and these will afford an opportunity of doubling up circuits, and finding new working conditions. There is a limit, however, and the occasional newspaper article about being able to catch the minutest modulations of a trans-oceanic *prima donna*, and so on, will be well without that limit. The problem of telephony, when reduced to underground or submarine cables, is much more difficult. In New York and most other large cities, the conditions to be met in the local service are as bad as those in telephoning between cities. Talking the length of Manhattan Island through underground cables, with their increased capacity and their congested condition, fifty pairs of wires being contained in a single lead-covered cable of 1½ inches diameter, requiring the most careful balancing to eliminate all disturbing inductive influences of neighboring wires, is an achievement comparable with talking to a point a thousand miles away on an overhead construction.

The effect of dead resistance, the third factor, is merely to cut down the quantity of the current and consequently the volume of the sound. The intensity or amplitude of the vibration is changed, but the pitch and quality remain the same. It is possible to talk through 30,000 ohms of non-inductive resistance. Conversation through the resistance of the body is readily carried on. The resistance in itself being of secondary account, and the self-induction in a copper wire being almost negligable, capacity stands preëminently the controlling factor. The relation between self-induction and capacity being a tendency to neutralize each other, advances may be looked for in the introduction of self-induction to overcome the ill effects of the capacity. This is being experimented on at the present moment, and underground cables which have made speech thick and stuffy when transmitted have been cleared up experimentally to a great extent. This is, of course, at the expense of the current, but the wonderful power of the ear makes up for this. This discriminating power of the ear, which is shown in what is known as the Fechtner-Helmholtz psycho-physical law, is of the highest importance to telephone engineers. It has never been translated into English, but may be stated somewhat as follows: If the intensity of sound changes in arithmetical progression, the effect upon the ear varies logarithmetically; and shows in what an enormous proportion we must increase the intensity of vibration in a telephone, if we want to double the effect, and, on the other hand, in what enormous proportion we can diminish such intensity without perceptibly diminishing the effect.

The hope of indefinitely extending the long distance telephone lies in some compensating device whereby the effect of capacity can be overcome, and the tuning up of a telephone line—much as a piano string is tuned up may—become ordinary practice.

SOME NOTES ON ROPE DRIVING.

BY J. J. FLATHER.

PART I.

A few years ago rope driving was an experiment in certain work; it is now a competitor with toothed gearing and leather belting; especially so where the amount of power to be transmitted is large, or the distance between the motor and the work is comparatively great. For such special cases where the power is transmitted to a pulley whose axis is in a different plane from that of the driver, a rope transmits its full power, whereas a leather belt loses a part of its grip, and it is often inconvenient to use bevel gears; but it should be noted that, in general, rope driving is not as economical in the transmission of power as leather belting, and should not be made to replace the latter in ordinary machine shop transmissions. Rope driving is especially satisfactory where the power transmitted is large, otherwise requiring very wide and troublesome belts; also where the driving and driven shafts are at an angle with each other, where a vertical drive is required, where the distance is great, and when the speed of rope is high.

Among the materials used in this method of power transmission we find manila rope in much favor. For special purposes, similar ropes made of cotton are also used, although in England cotton ropes are generally preferred and largely employed for main drives, for running traveling cranes, and for intermediate driving of all descriptions; though this may be due more to the fact that rope driving was introduced by the cotton spinners to replace gearing, and, naturally, cotton was the material with which they were most familiar. In the mills of Dundee and vicinity, where flax and hemp are worked, we find ropes of hemp used entirely. Raw-hide ropes are also used to a limited extent. For railway and other haulage systems, and for long distance transmission, we find wire ropes or cables used almost exclusively. As manila rope is used so extensively for the purposes of power transmission, we shall confine the limits of the present paper to its discussion.

Although the general terms usually employed in connection with ropes and cordage may be familiar, the following glossary will be convenient to refer to if occasion may require:

Yarn.—Fibres twisted together.

Thread.—Two or more small yarns twisted together.

Strand.—Two or more large yarns twisted together.

Cord.—Several threads twisted together.

Rope.—Several strands twisted together.

Hawser.—A rope of three strands.

Shroud-Laid.—A rope of four strands.

Cable.—Three hawsers twisted together.

A rope is: *Laid*, by twisting strands together in making the rope.

Spliced, by joining to another rope by interweaving the strands.

Whipped, by winding a string around the end to prevent untwisting.

Served, when covered by winding a yarn continuously and tightly around it.

Parceled, by wrapping with canvas.

Seized, when two parts are bound together by a yarn, thread, or string.

Payed, when painted, tarred, or greased to resist wet.

Manila or, more properly, manila hemp (abaca) rope, is made from the fibres of the *musa textilis*, a plant allied to the banana, growing near Manila in the Philippine Islands. The fibres are composed of very fine and much elongated cells, held together by a vegetable glue, which look under a microscope like a bundle of pipes cemented together. These fibres are of great strength in the direction of their length, but are weak transversely.

To obtain fibres of suitable size for manufacturing rope, the stems are subdivided and the cells separated into small bundles or congeries, which process leaves the surface rough and uneven. When made into rope these rough fibres are compelled, in bending over the sheave, to slide on each other while under pressure from the load. This causes the internal chafing and grinding which, if not prevented, soon wears out a rope when subjected to bending strain.*

In addition to the action of the fibres upon each other, the strands and the yarns of which the strands are composed, also slide a small distance upon each other, causing friction, and hence internal wear.

By opening out an old dry rope which has been used over a sheave, a fine powder will be disclosed, showing that where the rope was bent over the sheave, the strands, in sliding on each other, ground some of the fibres to powder. Another reason for this is that by constant flexure the vegetable glue, which cements the unit fibres, cracks and disintegrates. Aside from the external wear which a rope suffers from contact with its sheave, part of which is the differential driving effect (see page 21), these two are the principle causes of rapid wear in a rope drive, to remedy which we must in the first case lubricate the fibres, and in the second, prevent undue flexure of the rope. How this is carried out in practice will be seen presently.

In manufacturing rope the fibres are first spun into a yarn, this yarn being twisted in a direction called right hand. From 20 to 80 of these yarns, depending on the size of the rope, are then put together and twisted in the opposite direction, or left hand, into a strand. Three of these strands for a 3-strand, or four for a 4-strand rope are then twisted together, the twist being again in the right hand direction. It will be noticed that when the strand is twisted it untwists each of the threads, and when the three strands are twisted together into rope it untwists the strands but again twists up the threads. It is this opposite twist that keeps the rope in its proper form. When a weight is hung on the end of a rope, the tendency is for the rope to untwist and become longer. In untwisting the rope it would twist the threads up, and the weight will revolve until the strain of the untwisting strands just equals the strain of the threads being twisted tighter. In making a rope it is impossible to make these strains exactly balance each other, and it is this fact that makes it necessary to take out the turns in a new rope—that is, untwist it when it is put at work.

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* A writer in Vol. XII of the Transactions of the A. S. M. E. claims superiority for the cotton rope on the ground that, the fibres being integral, with smooth surfaces, there is much less tendency toward this internal chafing and wearing. EDS.

There is, however, a difference in judgment among different makers as to the exact amount that should be used for any specific work. The greater the twist the more hard and rigid the rope is, and the better it will keep its form, but it is not quite as strong, because the fibres do not lie exactly in the direction of the center line of the rope, but at an angle with it, and the greater the twist the greater is that angle. The difference, however, is slight in practice.

Lubrication is provided for in various ways, a very efficient method being that in which the rope is laid up in a mixture of plumbago and tallow. This lodges in the hollows and uneven places among the fibres, and thoroughly lubricates the strands and yarns of the rope. After running a short time the exterior of the rope becomes compressed and coated with the lubricant, which, in a measure, makes the rope water-proof.

Sometimes the strands are laid up about a center core of plumbago or of soap-stone; frequently the rope is laid up in tallow alone, or it may be that the only lubrication the rope receives is obtained by tarring the yarns, which process, however, weakens the rope materially.

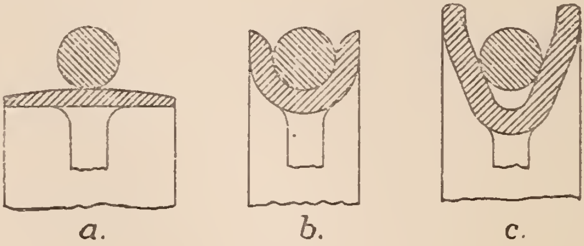


FIG. 1.

The pulleys employed in rope driving are usually of cast iron with a groove or grooves, as the case may be, turned or cast in the rim over which the rope runs. If the groove is semi-circular as at *b*, Fig. 1, the friction will be but little greater than if the surface were flat as at *a;* if, however, the groove is made wedge-shaped as at *c*, the driving power will be increased, although the surface of contact is reduced. When only a small amount of power is to be transmitted the rope rests upon the bottom of the groove, which is the case also when the pulley merely acts as an idler, but in most cases the rope rests against the sides of the groove, and is wedged between them so that the frictional resistance to slipping is increased thereby.

The sides of the groove vary ordinarily from 30° to 60°—the best angle to use in any given case will depend upon the tension in the rope and the condition of the latter. A mean angle of 45° is used by a number of engineers, although, when ropes are lubricated with tallow, lard or other grease, a smaller angle should be employed in order to increase the friction, as the greasy rope is apt to slip. On the other hand, a heavy stress and a dry rope will cause the latter to be wedged tightly into a narrow groove, thus producing undue wear and causing a loss of power in transmission. In cases where there is considerable difference in diameter of pulleys, it will be an advantage to make the angle of groove greater in the larger wheel, for, since the arc of contact is greater on the larger sheave its coefficient of friction should be less, in order to equalize the pull on the ropes.

Since the actual coefficient of friction is proportional to the cosec. of half the angle of the groove, it will be evident that if a larger angle be used the coefficient of friction will be reduced.

In practice we frequently find the grooves in the large driver with an angle of 60°, while the grooves in the follower have angles of 45°. For average work the proportions and form of groove shown in Fig. 2. will be found to meet the requirements of good practice. In this case the angle of groove is 45°.

The bottom of the grooves is sometimes filled with wooden blocks dovetailed into a channel cast to receive them. After being fitted and secured, the groove is turned out to the desired shape and trued up. Gutta-percha, rubber, leather, tarred hemp, and other substances have been used for the same purpose, but as a rule cast iron is preferred as a contact surface and we find these groove linings confined in most part to pulleys used in wire rope transmissions.

It is a matter of importance that the whole surface of the groove should be turned smooth and carefully polished, as the fibres of the rope, rubbing on a rough-turned or cast surface, will gradually break, fibre by fibre, and thus give the rope a short life. It is also necessary to avoid using any pulley with sand or blow holes in the groove, as they will cut the rope out with a surprising rapidity.

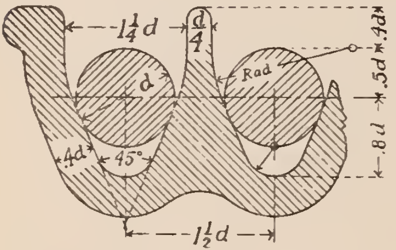


FIG. 2.

The size of the pulleys has an important effect on the wear of the rope — the larger the sheaves, the less the fibres of the rope are flexed, and the less they slide on each other; consequently there is less internal wear of the rope. The pulleys should not be less than thirty-five to forty times the diameter of the rope for economical wear and as much larger as it is possible to have them; this applies to all pulleys in the system — guide and tension pulleys as well as main driving pulleys.

As a certain amount of force is required to bend the rope around its sheave, it will be evident that the loss of power in transmission will vary inversely as the diameter of sheave for a given rope; for ropes of different diameters this loss increases in a ratio proportional to the square of the diameter.

Much depends also upon the arrangement of the rope on the pulleys, especially where a tension weight is used. Experience with manila ropes has shown that the effect caused by bending the rope first in one direction and then in the other, increases the wear of the rope very materially. As far as possible the pulleys should be arranged to bend the rope in one direction only.

Usually the horizontal distance between the pulleys is 20 to 60 feet, but in many cases the latter distance is more than double.

It is desirable to arrange the drive with the ropes horizontal or inclined at an angle rather than use direct vertical drives; this latter method, however, is used to a large extent, and has in its favor a much greater economy of space.

There are two methods of putting ropes on the pulleys: one in which a number of single ropes are spliced and run side by side in a series of grooves; the other, generally known as the American system, is that in which one rope is wrapped as many times around the pulleys as is necessary to obtain the required horse-power. With this latter method a tension pulley and weight is used to give the necessary frictional resistance, and to take up the slack, while in the former case each rope is stretched sufficiently taut when first put in place; when slip occurs a new splice is made. It is advisable to have the driving side of the rope on the lower side of the pulleys and the slack side above; then, in driving, the two sides approach each other, and the arc of contact is increased. The slacker the ropes are, consistent with obtaining sufficient frictional resistance to slipping at the pulleys, the less are they squeezed into the grooves, and hence the less the wear and loss of power.

One of the principal causes of external wear in a rope, and also a large factor in the loss of power transmitted in independent rope drives, is the differential driving effect produced by varying efforts of the several ropes to set up independent velocities in the driven pulley. The resulting velocity will be a mean of the several efforts, so that slipping of some of the ropes must occur.

It is evident that in order to prevent slip, and the evils incident thereto, it will be necessary to obtain a uniform velocity in the several ropes running over a pair of pulleys; to approach this desideratum each set of ropes should be of the same make and diameter, installed at the same time, similarly spliced, having the same amount of sag, and running over grooves of uniform diameter.

(To be concluded in the next number.)

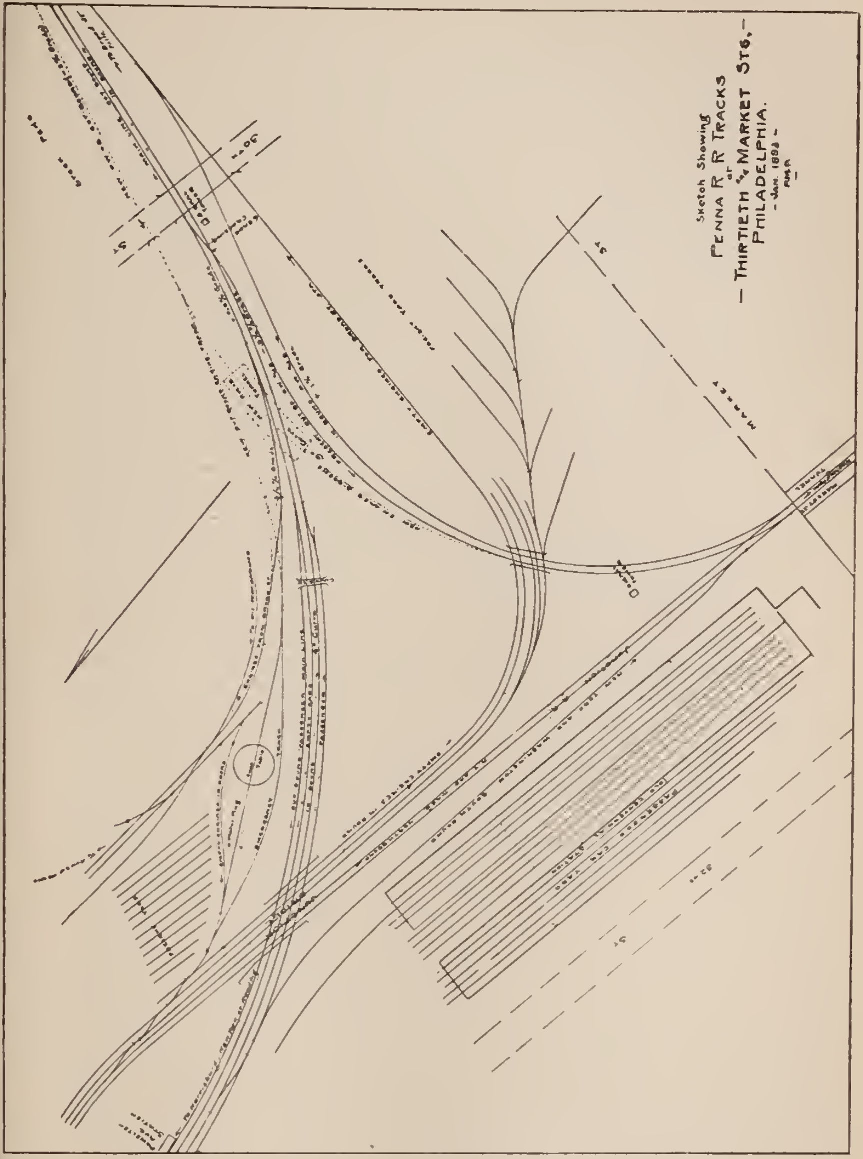
IMPROVEMENTS ON THE PENNSYLVANIA RAILROAD AT THIRTIETH STREET, PHILADELPHIA.

Before beginning the discussion of the subject of this paper it may interest the readers of THE QUARTERLY to learn something of the locality where the improvements are being made.

The piece of land shown on our sketch, between Thirtieth and Thirty-Second Streets, north of Market Street, Philadelphia, is said to be the best utilized piece of railroad property in the United States. The main line tracks pass through, from Broad Street station, by way of the "Elevated," toward Powelton Avenue station, at an elevation of about 30 feet above the level of the street. At Thirtieth Street the out-bound Philadelphia, Wilmington and Baltimore trains turn southward, and run "down the hill" to disappear in the tunnel at Thirty-Second and Market Streets, while the in-bound trains over the same line come up an easier grade and reach the elevation of the main line just west of the Schuylkill River.

A few hundred feet west of Thirtieth Street a turnout from the out-bound main track to the right carries the engines which have finished their runs, down the hill to the round-house or the shops, and leading off from this to the left, and following the main tracks, but at the foot of the slope, is the "emergency track," for the use of main line trains in case the tracks to the west should become blocked. A short distance further, and the two main tracks separate into four, to give room for the trains of "empties" which are continually passing between the passenger car yards and Broad Street station. These four tracks pass over what is called in railroad slang, the "Junk Bridge," (short for Junction Railroad) and thence to Powelton Avenue station.

Trains from New York to Washington, whose time is too limited to allow them to visit Broad Street, leave the in-bound main track between this bridge and Powelton Avenue, and when the engineer "gets the white" instead of the green signal, he coasts slowly down the hill and joins the P. W. & B. at the mouth of the Market Street tunnel. Under the "Junk Bridge" passes the Junction R. R., the main connecting link between the Pennsylvania and Reading roads. There are also two freight tracks be-


Sketch Showing
PENNA R R TRACKS
at
– THIRTIETH and MARKET STS, –
PHILADELPHIA.
- Jan. 1883 -
RMR
MARKET
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side the track (marked by arrows in the sketch) which carries the empty engines from the round house to go on duty at Broad Street. Coming out of the round-house they appear on our diagram near the left hand upper corner. They back through the swith near the turn-table, run forward, take water if necessary, run through another switch just south of the freight yard, back under the bridge, across the P. W. & B. above grade, and so to the in-bound track near Thirtieth Street.

It is, indeed, a well utilized piece of ground, so well utilized that it is hard to see, without considerable study, how improvements of any kind could be made. There are no important street crossings at grade; all turnouts from the main track are governed by interlocking switches, and a wonderfully large number of independent movements can be made. But delays between Broad Street and the city limits still occur and traffic is increasing every year. More trains must be handled in a shorter time and with less delay. Especially is this true in view of the large increase of business expected next year on account of the Chicago Fair.

The most important change of which we shall speak consists in abolishing the grade crossing of the P. W. & B. south-bound, at Thirtieth Street.

Under the present arrangement all south-bound trains from Broad Street must slacken speed at this point, and cross the main in-bound at grade before running down the hill to the Market Street tunnel. Now five hundred regular passenger trains passed this point every twenty-four hours during the Summer on three tracks. Of these, seventy-nine crossed the main in-bound track at Thirtieth Street, moving south. Those interested in the theory of probabilities can easily determine that the chances of an in-bound train being held for a south-bound, or the reverse, are very good, indeed.

The remedy, very simple in theory but somewhat difficult in application, was suggested by Mr. Gucker, Superintendent of the Philadelphia Division, and preliminary surveys and a plan showing the proposed change were made by the Philadelphia Division Office in December, 1891. The dotted line in the sketch shows the arrangement. South-bound trains will leave the main line by a switch operated at Twenty-Third Street, the frog being located just west of the Schuylkill, and, turning to the right, will run down a comparatively easy grade on a tangent curving to the south to enter a tunnel under the main line, and join the present track as shown on the sketch.

Some of the features of the problem were these: Thirtieth Street must be crossed by a bridge high enough to give proper clearance; the proposed tunnel must be built without shifting the main tracks any great distance either north or south; the track for engines from Broad Street must not be thrown out of service for more than a few hours at a time, neither can its connection be moved west to any extent, because the grade—3½ per cent.—is already heavy enough, and the further the connection is moved west the heavier will the grade become.

And finally, passenger trains must not be held nor their speed slackened on account of the work.

I can only speak briefly of the different steps of the operation. The in-bound track was first placed upon a trestle made of oak-piles driven four abreast flush with the ground and about 15 feet south of the former position of the track. The engine track connection was next shifted as far west as possible (about 50 feet) the grade being increased to 4½ per cent. and this permitted work on the first section at the east end of the arch to commence.

Next, the out-bound track, with the engine track connection, was moved to a position parallel to the in-bound and standard distance (12 feet 2 inches center to center) from it. More arch was sprung and the engine track carried over it on trestle, being connected further east. Meanwhile the bank was dug away from around the pile trestles, leaving about four feet in the ground. The bents were braced together as the work proceeded.

Next, both main tracks were placed on framed trestle work, crossing the part of the tunnel already finished on a tangent, with 8 degree curves at each end. This leaves the field clear for the completion of of the masonry, after which the tracks will be thrown to their former positions; a separate New York Division in-bound and New York Division out-bound being added. These tracks will run parallel to the main line as far as Thirty-Third

Street, where practically the same scheme for avoiding a grade crossing is already in operation.

An interesting feature of work of this kind is the fact that owing to the large number of trains passing during the day it is necessary that all important changes in track, "cutting and throwing," shall be done between the hours of 12:30 at night and three in the morning.

The construction of the approaches and masonry is being done mostly by contract under the supervision of the engineers of the construction department. The changes of track and erection of trestle work is in the hands of the M. W. Department of the Pennsylvania Railroad, under the Assistant Engineer of the Philadelphia Division.

PAUL M. PAINE, '91.

AN INTERESTING PROBLEM.

Theoretical investigation to determine whether a square shaft may be made stronger by removing a certain amount of material from the corners.

The shaft is supposed to be subjected to torsional stress, and from the principles of the strength of materials we have the relation between the twisting moment Pp, applied to the shaft, and the resisting moment of the shaft, given by the equation

$$Pp = \frac{SJ}{c} \qquad (a)$$

where S is the maximum permissible stress, J is the polar moment of inertia of the cross section about the central axis of the shaft, and c is the distance from the centre to the most remote fibre under stress. Since S is a constant for any particular case, the resisting moment, and consequently the allowable load, varies directly as $\frac{J}{c}$. Our investigation resolves itself into a determination of the law of variation of $\frac{J}{c}$ for change of the section by the removal of material from the corners—it is a problem in moment of inertia.

Figure 1 represents such a shaft, originally square, in which the corners have been chamfered along the 45° lines AB, CD, etc. We make the ratio of CL to KL the independent variable, so that $\frac{CL}{KL}=\frac{AK}{KN}=k.$

To find the moment of inertia we divide the octagon into eight triangles by the diagonals AE, BF, CG, DH. Then O is the centre of the section, and $OC=c$.

The polar moment of inertia of a triangle with reference to an axis through its vertex is made up of the two polar moments about a pair of rectangular axes through that point; our triangles are all isosceles, so that, if h be the altitude and b the length of the base of the triangle, the moment J is

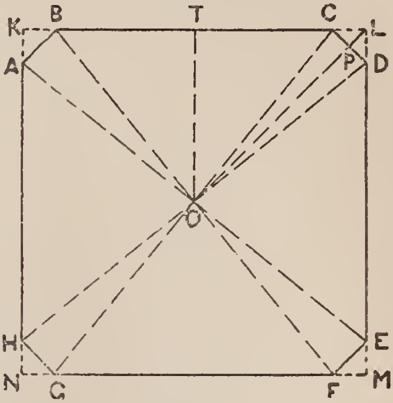

FIG. 1.

$$J=\frac{1}{4}bh^3+\frac{1}{48}b^3h=\frac{1}{48}bh\left(12h^2+b^2\right) \qquad (b)$$

In the triangle COD, $CD=b=kd\sqrt{2}$, and $OP=h=OL-PL=\frac{1}{2}d\sqrt{2}=\frac{1}{2}kd\sqrt{2}=\frac{1}{2}\left(1-k\right)d\sqrt{2}$, where d is the diameter of the shaft, KL, and k has the meaning given above. Then by substitution we have for the triangle COD,

$$J_1=\frac{1}{48}\left(k-k^2\right)d^2\left[6(1-k)^2\,d^2+2k^2d^2\right]$$

$$=\frac{1}{24}\left(k-k^2\right)\left(3-6k\times 4k^2\right)d^4 \qquad (c)$$

In like manner for the triangle COB, $CB=b=(1-2k)\,d$, and $OT=h=\frac{1}{2}d$; whence

$$J_2=\frac{1}{96}\left(1-2k\right)d^2\left[3d^2+\left(1-2k\right)^2d^2\right]$$

$$=\frac{1}{24}\left(1-2k\right)\left(1-k+k^2\right)d^4 \qquad (d)$$

The moment J for the whole figure is given by $J = 4J_1 + 4J_2 =$

$$\frac{1}{6}\left[(k-k^2)(3-6k+4k^2)+(1-2k)(1-k+k^2)\right]d^4 =$$

$$\frac{1}{6}\,(1-6k^2+8k^3-4k^4)d^4. \qquad (e)$$

Now $CO = c = \sqrt{OP^2 + CP^2} = \sqrt{\tfrac{1}{2}(1-k)^2d^2 + \tfrac{1}{2}k^2d^2}$

$$= \sqrt{\tfrac{1}{2}}\sqrt{1-2k+2k^2}\,d \qquad (f)$$

Hence we have for the value of $\frac{J}{c}$,

$$\frac{J}{c} = \frac{\sqrt{2}}{6}\,\frac{1-6k^2+8k^3-4k^4}{\sqrt{1-2k+2k^2}}\,d^3 = \frac{\sqrt{2}}{6}\,md^3 \qquad (g)$$

In this expression $\frac{\sqrt{2}}{6}d^3$ is constant, and we have only to investigate the variation of the factor in terms of k; calling this factor m, we find by successive evaluations,

for $k = 0.$ $m = 1.$
$k = 0.05$ $m = 1.038$
$k = 0.10$ $m = 1.047$
$k = 0.15$ $m = 1.032$
$k = 0.20$ $m = 0.990$

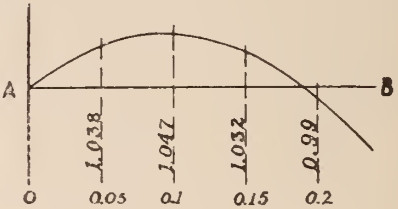

FIG. 2.

Plotting these results, we obtain the curve in Fig. 2; the values of k are abscissas, and those of m, measured from the line AB which correponds to $m = 1$, are the ordinates. This curve shows that the strength increases to a maximum near $k = 0.1$, and then diminishes with increasing rapidity.

To make the solution exact, we must find the value of k corresponding to the maximum, which is done by putting $\frac{dm}{dk} = 0$:

$\frac{dm}{dk} =$ a lengthy expression, which reduces to

$$\frac{dm}{dk} = \frac{1-14k+42k^2-68k^3+60k^4-24k^5}{(1-2k+2k^2)^{\frac{3}{2}}} \qquad (h)$$

Hence we have the equation

$$1 - 14k + 42k^2 - 68k^3 + 60k^4 - 24k^5 = 0$$

to be solved for k.

By applying Sturm's theorem to this equation we find that it has only one real root, which lies between 0 and $+1$; and by successive trial evaluations we find the root to be

$$k = 0.095.$$

For this value of k, $m = 1.047$; that is, when the corners are cut so that $k = 0.095$, the strength is at the maximum, and is four and seven tenths per cent. greater than that of the square shaft. Fig. 1 is drawn with proportions corresponding to this value of k, and gives a good idea of how much should be removed. To go into the matter very exactly, the greatest strength will be obtained by turning off the corners instead of cutting them along a straight line; the area is increased by a small segment of a circle on each corner while c remains the same; but the increase is practically almost infinitesimal.

The practical accuracy of this discussion depends upon the closeness with which the law of equation (a) represents what actually takes place; and for an experimental verification, where the margin of difference is so small, a large number of carefully observed trials would be necessary. The practical lesson is one that common sense would suggest, namely, that it is better to have the maximum stress distributed over even a narrow face of the shaft than concentrated on a fine edge. Theory verifies this and sets the limits to it. If the writer were designing a square shaft for heavy strains, especially for shocks, he would cut off the corners.

ROBERT C. H. HECK, '93.

GLACIAL REMAINS AT BAR HARBOR.

Bar Harbor is situated on the lovely island of Mount Desert which is bounded on the east by Frenchman's Bay and on the south by the sea. The island consists of a ridge of mountains running due north and south, of which Green Mountain is the highest, rising over 2000 feet above the water. These mountains are separated by deep gorges which appear to have been ground deeper by the ice. East from Bar Harbor and directly across Frenchman's Bay are Grindstone Neck and Scoodic Point, separated from each other by Winter Harbor.

That the ice must have been of tremendous thickness in this region is proved by the fact that the highest point, Green Mountain, is rounded off, and in the outline of its curves shows unmistakeable signs of glacial action. The glacial remains of this region, comprising scorings, boulders which have been deposited by the ice and moraines of all descriptions, are remarkably clear and unmistakable in their character. The whole country is of Plutonic origin, the mountains rising directly from out of the sea, forming the most beautiful scenery in New England. For the sake of clearness I will describe the three different kinds of remains separately. But first I would like to speak of a curious phenomenon occurring at what is called Scoodic Mountain. This mountain forms the rib of a narrow peninsula running out into the sea and setting the eastern limit to Frenchman's Bay. On the landward side it slopes gradually upward over a succession of hillocks and then abruptly terminates in a bold precipice looking out over the Atlantic Ocean. It seems as if the ice in its advance had caught hold of a projection of some sort and exerting the tremendous force due to its onward movement had wrenched the mountain asunder, tumbling the seaward end into the water, where it sticks up to-day, forming with its present mass a sort of inland sea, which is bare at low water and constitutes a veritable paradise for the blue heron, ring-necked plover, and other birds delighting in marshy lands.

The glacial scorings throughout all this region are very well defined and in all cases run due north, and south, except where the ice has been deflected in passing over any hill of considerable size. In this case the lines point north-west and south-east on the landward end of the eastern side of the hill, and north-east and south-west on the seaward end. The lines, if continued around the whole hill, would form ellipses, whose conjugate axes would lessen as they approached the summit, the transverse axes running north and south, until at the top they would pass into a straight line running north and south as before. Where the mountain has risen abruptly out of the water it would seem that the ice had overlapped the shore rocks, as there are some instances in which no scorings appear near the shore, although occurring further up the mountain. On low necks of land, however, the ice has abraded the shore rocks, rubbing them smooth even for a great distance under the water. Often dikes occur along the seashore, consisting of a volcanic rock rising out from between the granite walls. The granite has sometimes been worn away underneath, and tumbled down, leaving the dike-rock standing out alone. On the top of these the scorings appear quite plainly, showing that the granite was once on a level with the dike. These dikes partake a good deal of the nature of trappes, sometimes appearing as isolated pillars standing out of the water a few feet from shore. I could not form any estimate of their length as they soon disappeared under the soil.

Boulders of rock, differing widely from anything found in the neighborhood, are often found sprinkled over the land. One of great size, in form a roughly shaped sphere, stands in the yard of the Louisburg Hotel in Bar Harbor. Its diameter is about fifteen feet, and it has been split open by six small blasts, one-half having been taken away, while enterprising Young America uses the flat surface of the other as a back-stop for his base-ball diamond.

The moraines were probably not formed by the great mass of the ice, but on its retirement•a portion took refuge in the gorges between the mountains where it formed small glaciers which held out quite a while against the ravages of the advancing heat. The best instance of this occurs in what we will call Sommes' Sound Glacier, which was the largest in the neighborhood. Sommes' Sound is an arm of the sea running due north into the heart of the island. At first it passes through a narrow gorge which, I have been told by those who have seen both, resembles the Norwegian Fiords. On one side of this gorge is a precipitous cliff called Echo Rock, rising straight out of the water to a height of between two and three hundred feet. On the other side the mountain is more sloping, although higher in the end than Echo Rock. Farther inland the mountains separate, leaving a placid bay bosomed in their midst. Now, the greater mass of ice of the Sommes' glacier, entering from behind, and not being able to squeeze through the narrows, rose up the mountain side, and curving down again upon the main glacier, after passing Echo Rock, the two went along side by side, forming a medial moraine, until they both broke off into the sea. Upon this moraine the village of South West Harbor now stands, while accross the harbor is North East Harbor, built upon the inner one of three consecutive terminal moraines which enclose the harbor. All that is left of the outer one of these three moraines is a few islets which are, however, arranged in the general form of a crescent. These are mere suppositions of my own, backed by no authority, but I see no other way in which to account for the curious phenomena occurring on the southern side of Mount Desert.

Another glacier having a curious formation was that occupying what is now called the Mill Stream. Here two separate glaciers, one from the northern and the other from the southern slope of Scoodic Mountain, came together, and although part of the ice broke out of the sea by three small openings, the great mass of it—it was only about a mile long—melted where it stood, depositing rubbish and boulders nearly sufficient to fill up the cavity of the mountain in which it rested.

The largest island in Frenchman's Bay, called Iron Bound, affords a striking example of the abrading ability of glaciers. Commencing at the level of the sea on the northern side, it slopes gently upwards until, at about half a mile's distance from its northern shore, it breaks off abruptly in bold cliffs about thirty feet high. The other islands—or rather islets, they are so small—are simply rounded hillocks, smoothed by the ice, rising out of the water and covered with pine trees. They have, therefore, received the name of "The Porcupines."

In the glacial action on the coast of Maine we see the utility of that vast field of ice which once covered nearly the whole of North America. The Plutonic rocks, rising sharp and jagged with steep sides and rough, broken outlines, on which no soil could rest have been converted into rounded hillocks, with gentle slopes, upon which was laid the foundations of the soil, consisting of the products of abrasion, so that today Maine, in spite of its high latitude, has a comparatively rich vegetation, and is thus rendered habitable to man.

WM. V. PETTIT, JR., '94.

THE LEHIGH UNIVERSITY SUPPLY BUREAU.

Believing that some account of this organization might not be uninteresting to the readers of The Quarterly, and that, in any case, the records of its establishment have a certain amount of potential historical value, the editors have asked from the Directors of the Bureau a description of its form of organization, its methods, and its objects, and have received the following statement:

One who has not given the matter a little serious thought is not likely to realize what an amount of money is spent here for books and supplies. The University *Register* estimates the yearly expense of books, stationery, etc., at from $25 to $50 per student. There are over 560 students here, and they, at $25 each for books, would spend over $14,000 a year. The drawing instruments and supplies which must be procured during the Freshman year cost at least $3000. The prospect of saving from five to fifty per cent. on all students' supplies, and the obvious advantages that would accrue from a purely coöperative association led to the institution of such an organization under the title of The Lehigh University Supply Bureau.

This is essentially a students' organization. At a college meeting held December 9, 1892, it was formally organized by the students. The consent and approval of the President and Faculty of the University was obtained, and a very desirable room in Christmas Hall was granted to the Bureau.

That it might be more thoroughly a students' coöperative association, the directors decided that they should receive no compensation for their services. Every student was to be considered a member unless deprived of such membership by the Board of Directors. This Board of Directors consists of ten students; four Seniors, three Juniors, two Sophomores, and the secretary of the Freshman Class *ex officio*. Those who organized the Bureau and drew up its constitution were chosen as the first Board of Directors. The members of this Board serve during the remainder of their college course. Four new directors are elected each year by the students, one from the Junior, one from the Sophomore, and two from the Freshman Class. The election is held during the week before Easter, each class choosing its own representatives. The new directors enter their office at the opening of the University after the Easter recess. At the same time the four Seniors retire from office. But the Board of Directors, thinking it best not to trust too much to the fickleness of college elections, retain the privilege of nominating the candidates, three for each office; the election, however, being by the classes to which the respective nominees belong.

The Board of Directors while they have retained full control of the executive and monetary part of the Bureau, and are responsible to the students, have appointed a manager to attend to the details of the business. This manager is responsible to the Directors and receives a compensation for his services. The funds remaining after all debts have been paid shall go to form a sinking fund, to be used only in case of emergency, thus giving some stability to the organization.

That the students may at any time know the standing and condition of the Bureau, an auditing committee may be appointed by the students at a college meeting, who shall be allowed to examine the books and stock of the Bureau. In addition to this, however, an annual report of the business of the preceding year will be made by the directors at the end of each fiscal year, *i. e.*, at the time of the annual election of directors.

A bulletin board and box have been placed in Packer Hall for the use of the Bureau, and to give information to the students.

Unlike organizations of this kind at other colleges, students are not charged for the privileges of the Bureau. Books are sold on subscription only. The business is transacted on a strictly cash basis, thus relieving the Bureau from any danger of financial embarrassment. Drawing instruments, drawing supplies and text books are all that have as yet been handled, but it is hoped that the Bureau may in time control the purchase of all students' supplies.

While it is rather early in the history of the Lehigh University Supply Bureau to tell much about it, or predict much concerning its future, still, so far, its main object has been accomplished.

Prices have been lowered in all the book stores. As an extreme example, one book dropped from $5.10 to $3.40. It was not until such an enterprise became almost a necessity that the Directors decided to organize the Bureau, but now that it has been started we think every student should and will desire to see it become a permanent college institution.

In conclusion, a few words concerning a plan which the Directors would like to see carried through, will be very fitting. It often happens that a text book goes out of use at one college while it is still used at another. Would not an Inter-Collegiate Bureau Exchange be a useful and profitable thing? Exchange of books and correspondence would be advantageous both by reason of the profit derived, and of the experience obtained. But as yet this is only a plan.

SECRETARY OF THE BUREAU.

THE ENGINEERING SOCIETY.

The Engineering Society is in a prosperous condition. The membership has risen to about seventy-five, and the payment of the old debt has placed the Society on a sound financial basis. This debt of $130 was left by the deceased *Journal of the Engineering Society* two or three years ago; the Society was not legally responsible, but assumed the obligation as a debt of honor, and has paid it off in installments.

The meetings are largely attended, and many papers of great interest have been read. Among them are the following; "The Construction of Sewers at Elmira, N. Y.," by C. S. Haynes, '93; "The Graphical Determination of Moment of Inertia," by R. C. H. Heck, '93; "Bridge Design," and "The Design of the Details of a Pratt Truss," by A. Schotte, '93; "The Jeddo Tunnel," by C. L. Olmsted, '93; "Masonry and Pile Foundations," by R. Ferriday, '94; "A Sketch of the life of Col. Julius W. Adams," by G. H. Frost, '93; and, "The Manufacture of Chrome Steel," by W. S. Dunscomb, '94.

THE VISIT OF THE SENIOR MECHANICALS TO PHILADELPHIA.

Under the guidance of Mr. Dahlstrom the Mechanicals of 'Ninety-Three enjoyed a series of very interesting and instructive visits of inspection at some of the principal shops of Philadelphia on the 19th, 20th, and 21st of January. A short account of the most remarkable machinery seen, and of the novel points of engineering practice to which their attention was called, may not be inappropriate to the pages of the QUARTERLY.

In the machine shop of Bement & Miles were a number of very heavy tools in process of erection; among them was a machine for planing the edges of armor plate, presumably by means of a rotary cutter* similar to those used on large slab-milling machines, having the cutting tools not on its periphery but on its inner side. The cutter is mounted on a carriage, which has a horizontal motion on the ways of the machine, and just passes beneath an overhanging shelf, on which rests the plate to be operated upon, the cutter projecting above the edge of this shelf. Another special tool was a "wall planer" for the heaviest class of marine work. The cutting tools move and the work stands still, so that the machine is on the principle of the shaper; the special point here is that the tools move in horizontal guides in a large vertical carrying plate, which is supported by standards along the side of the bed, and has itself a certain amount of vertical motion; of course, only the vertical side of a piece of work can be planed at one setting up.

The shops of Wm. Sellers & Co., where a great deal of heavy machinery is produced, were passed through rather hastily; the principal object of interest was the great electric traveling cranes, of which several were in course of construction. They were to be seen in operation at nearly all the places visited, the largest being the 100-ton cranes in the Baldwin Locomotive Works.

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* The cutter was not in place, but from the fact that it is driven by gearing, with consequent low speed, would appear to be of the nature of a milling cutter rather than a saw.

At the works of the Southwark Foundry & Machine Co., some very large castings were seen; the specialty here is steam engines, of several types. A tremendous Porter-Allen engine, tandem compound, the bed of which weighs about forty tons, was being built. The size and perfection of this, and other large castings, shows wonderful proficiency in the founder's art. This engine is intended for rolling-mill work, and is to develop an average of 3500 and a maximum of 4700 I.H.P., all on one crank, which gives an idea of the massiveness required in the moving parts. There were also on the floor of the shop a heavy combined engine and dynamo of 1000 horse-power for a station of the Edison Co. in New York, the engine being of the vertical compound type usual in such work, and a very large pumping engine with vertical steam, and horizontal water, cylinders, connection being made through a triangular walking beam. At this shop attention was called especially to what is a decidedly modern feature of shop practice, namely, the use of small, portable machine tools, driven by electric motors, which can be moved over and attached to various parts of very heavy castings; this is a great improvement upon the older way of being obliged to transfer the casting from one machine to another for the successive operations upon it. The use of electricity avoids a large amount of belting and shafting, and gives a system of great flexibility.

The Baldwin Locomotive Works are too colossal for even a mention of the many points of interest they presented; chief among these was the Vauclain Compound Locomotive. This engine has on each side two cylinders, with one cross-head and connecting-rod; a single piston-valve controls the distribution of steam in both high and low pressure cylinders. It is one of these engines that made the fastest time on record—a mile in 37 seconds—last November. The only point of shop practice that can be mentioned is the very extensive use of milling cutters to do work that was formerly done much less rapidly and effectively by other tools.

From Baldwin's to Pedrick & Ayers' was quite a transition; the latter manufacture high class machine tools of moderate size, making a specialty of the Richards open-side planer, and of milling machines. In this planer the tool has the traversing motion, as in an ordinary shaper, but instead of being placed on the end of a sliding bar, is carried on an arm projecting from the side of a cross-head which runs on guides. The end carrying the tool extends beyond the bed of the machine, the line of cut being parallel to the length of the bed, instead of at right angles to it; for many kinds of work this arrangement is more convenient than the usual style of shaper, and it gives great rigidity to the tool while cutting. In this shop especial care is given to all the small details of the machine made, and a degree of exactness maintained which is only practicable in first class machinery—there it pays and is paid for.

A visit to Mr. Hugo Bilgram's gear cutting establishment was very instructive. At Bement & Miles' a machine was seen planing theoretically correct bevel gear teeth by means of a template or former. Mr. Bilgram's machine dispenses with all such formers, and planes an exact tooth by giving the gear blank its proper conic rolling under a reciprocating tool whose profile is that of the involute rack—a straight line. The whole principle was fully and clearly explained, but cannot be given in detail in the space now available. Only one of these machines is at work in this country outside of Mr. Bilgram's shop, and that is at Brown & Sharpe's. Several kinematic curiosities were seen here, the chief of which was a set of three bevel pinions of 15, 20, and 25 teeth, each of which geared correctly with a bevel wheel of 40 teeth, the axes being at right angles in each case, and the contact exact. This is a good illustration of the possibilities of the involute system.

Last, but not least, was Cramp's ship yard. The cruisers New York and Columbia, which are nearly ready for their armor, were inspected, chiefly as to their engines; the machine shop was visited, and engines, shafts, and propellors were seen in all stages of progress toward completion. But, again, limits of space forbid going into details.

The visitors were everywhere received with courtesy, and with an evident desire to make their visit as pleasing and profitable as possible. For this, as well as for the valuable knowledge gained, their gratitude is due to those who welcomed them so cordially and conducted them so effectively.

EDITORIAL.

THROUGH the courtesy of the Faculty we are able to present as our frontispiece a perspective view of the new Physical Laboratory, made by the architect, Mr. Addison Hutton. The drawing gives a very fair idea of the general appearance and style of architecture of the building, and will, we think, be of especial interest to our alumni readers. Work upon the building has been going on all through the Winter, so that we may reasonably hope to see the statement of the prospectus verified, and the Electrical Department installed in its new quarters by September, 1894.

With pride we call attention to the article by Prof. Thomson on "The Life of Incandescent Lamps." The subject is of practical importance to the electrician, and involves much that is of great scientific interest. Prof. Thomson discusses the causes of the darkening of the bulb of the lamp, attributing it to the vaporization of the carbon of the filament and its eventual deposit upon the glass; since any irregularity in the filament, as to texture or purity, hastens this volatilization of the carbon, he concludes that the present trend of improvement must be in the direction of greater perfection in the details of manufacture; for there is no immediate prospect of the discovery of a suitable, non-volatile, substitute for carbon. The clear style of the article makes it comprehensible to all, and the prominence of the writer gives it an added interest.

The description of the educational methods of the great University so recently opened in California, by a Lehigh Alumnus who is engaged in teaching in that institution, must be of interest to all our readers. Prof. Richardson describes a system which is very different from our own, but which has much to recommend it. The elective system is not a new idea, but we doubt whether it has ever been made so completely the rule as at the Leland Stanford, Junior, University; for this reason, the trial of its working there is to some extent of the nature of an experiment—an experiment, which, according to the writer, is an assured success.

Mr. Honeyman in his paper on the long distance telephone, discusses, in a clear and scientific manner, the several influences which retard and destroy the transmitted sound impulses in a long line of wire. He believes that the present transmitters and receivers are sufficiently near to perfection for all practical requirements, and that the problems for the telephone engineer to solve are all in connection with the line wire. He places the limit of land transmission, through an overhead wire, very high, but thinks that long distance submarine telephoning is a much more serious and formidable problem.

What Prof. Flather has to say on the subject of rope driving will appeal chiefly to the mechanical engineer. After defining the field of usefulness of this class of transmission organs, stating their advantages, and giving the meaning of a large number of technical terms, Mr. Flather takes up the several points in detail, and in this paper discusses the causes and avoidance of wear in ropes, the designing of pulleys to secure the best results, and the arrangement of the several plies of rope in a drive; the subject is to be completed in our next number. Much valuable information is given in a clear manner and concise form; the paper is well worth reading, and will be useful for reference.

The article by Mr. Payne describes some details of practical engineering, and tells how work has been done, and well done, under great difficulties—difficulties which may be called artificial, but the overcoming of which probably costs more in time, and skill, and money, than the surmounting of some of the much greater obstacles that nature throws in the way of the engineer.

Mr. Pettit's description of Glacial Remains about Bar Harbor is written in an entertaining style, and gives evidence of careful and intelligent observation of phenomena, which, if their signs be read aright, tell us in clear and unmistakable language, the history of the time when those mighty forces of nature were at work.

WITH this number the QUARTERLY begins its third volume. As it enters upon another year, we may with advantage take a brief retrospect of its short life, to see how well it has carried out the purposes of its establishment and filled the field left vacant by its predecessor, the *Journal of the Engineering Society.*

The proper objects of a college technical periodical, stated in a few words, are these: to serve as a medium for the communication of scientific knowledge; to afford a repository for the useful results of the original work and investigation of the alumni and students of the college; and to encourage such original work among these same students and alumni, at the same time giving them an opportunity to cultivate good literary expression in embodying in words the results of their work. Leaving the second out of consideration, let us compare the first and last of these motives as to their relative importance.

We know that in any general scientific paper the first of these objects must be given decidedly the highest place. The question is not, who wrote it, but, will the public read it; the matter is more important than the man. The idea that benefit may accrue to a writer from the publication of his work will have very little influence with an average editor; in fact, the thought of such a paper asking for contributions on the ground that the preparation of them will be very good practice for the writers appeals at once to our sense of the ridiculous. But the college magazine does stand, to a certain extent, upon this very ground, nor is its position at all weak or illogical. We say that the imparting of scientific information, considered in the abstract, is not the only or the highest function of such a publication as the QUARTERLY; we do not, however, mean to imply that it has any right to publish what is useless or inaccurate or unscientific.

But the point is this: the college journal here enters a field which has been already fully occupied by the great engineering and technical periodicals outside; with its limited means and facilities, it cannot pretend to compete with them in absolute usefulness and value. Though it may, and, to be successful, must and does, publish only what is of interest and value to its readers, still, its right to exist cannot be based on this point alone. Its additional utility as a training school for men who are just beginning original work on engineering subjects, where they can have the stimulus of seeing their work in print, of hearing it criticized, and of being better able to criticize it themselves; this is what gives it a secure footing among college institutions. And the college publication is, in some ways, especially fitted to encourage the beginnings of such work. Its audience is not likely to be hypercritical ,and, if it maintains a fair standard of excellence in what it prints, it is pretty well assured of financial support by that college *esprit de corps* which makes a point of upholding college institutions as such.

We realize that the QUARTERLY could hardly carry on its work without contribution from professors, instructors, and friends prominent in the engineering professions; they fill our most interesting pages. They have our gratitude for their friendship and assistance, and we would be very reluctant to try the experiment of getting along without them. But we feel that if a journal such as ours were to depend only upon these sources, it would be far from fulfilling its ideal. When students and alumni cease to feel sufficient interest in their college magazine to write for it, they are very likely to cease caring to read it.

A review of the list of writers in the volumes already completed, gives us the impression that both extremes have been avoided; and for the future we intend to work along the same lines that previous progress has followed. We shall need, and be thankful for, all the help that our friends may give us; but we want to make a specialty of having a certain amount of good undergraduate work in each number, if it be possible to obtain this—and it has been possible in the past. We wish that contributions of this class might come in great numbers and unsolicited—and who knows but that the day may come, when the editors may enjoy the unheard of luxury of actually rejecting an article, of giving the waste basket something to fill its spacious emptiness. In no other way than by encouraging this kind of work can we better continue the efforts of our predecessors to make the QUARTERLY a first-class college technical magazine.

WE have to announce several changes in the Editorial Board. Mr. Symington, finding that the pressure of his University work, due to the fact that he is taking the studies of his course in less than the allotted time, was so great as to prevent him from doing justice to the position and to himself, resigned the Chairmanship after the last number was completed. His resignation was accepted with regret, on the condition that he should remain a member of the Board. Mr. Edwin C. Reynolds was elected in January as representative of the Civil Engineering department.

SOME apology is due our subscribers for the delays in the appearance of the first two QUARTERLIES of this year; the first was kept back by the slow arrival of contributions and by unforeseen hindrances during the publication; and the fact that it appeared just before the examinations was responsible for irregularity in mailing it. The lateness of the first number and the changes in the Editorial Board have put this issue several weeks behind time. We have reorganized our mailing department, and hope to give better satisfaction in this respect. The dates for the next two numbers are about the 10th of April and the 1st of June.

WE are glad to record the prosperous condition of the Engineering Society, but would like to offer a friendly criticism of the meetings. If the members who read papers would put a little time on elocutionary practice beforehand, and then read loud enough to be heard without great effort, they would be much more entertaining and effective. Not all are equally deficient in in this respect, but there are none whom a little such preparation would not have greatly benefitted.

THE Supply Bureau is introduced to our readers on another page. The purpose of the organization is its own commendation; we do not intend to offer any advice as to the best way of managing it, but extend to the Directors our best wishes that they may succeed in making it a strong and permanent institution.

THE adoption of the restrictive rule by the inter-collegiate league in New York, a short time ago, has excited widespread interest throughout all the colleges in the land; for all are affected by it. There are several reasons for this.

In general the moral athletic tone is formed and controlled by the larger colleges; and it is natural to suppose that a sweeping reformation of this kind in the League, would have a most benificent effect outside of its official scope.

Again, we smaller colleges have always been compelled to act as a source of supplies to the richer and older institutions, a most harrowing condition of circumstances. In the last few years there has been a great lessening of the difference between the teams of Yale, Harvard, and Princeton, and their smaller contemporaries. This growing equality has been strenuously fought, and financial inducements have not been scrupled at. In this state of affairs one of the smaller colleges can safely count on losing one or more of her best men every year. And we can feel sure that never, while exposed to this wholesale kidnapping, can we have the semblance of a fair show at Yale, Harvard, Princeton, University of Pennsylvania, or Cornell.

Right here is one other thing that appeals strongly to Lehigh men. The University of Pennsylvania has lately been enabled to outclass us a little. That will *surely* have an end under the new rule. Cornell also will feel her chances for the League to be very much smaller.

While *all* the provisions of the rule may not be perfect, still we are sure that its general effect will be most pleasing to the majority of Lehigh men, and it is our sincere hope that Walter Camp and his co-workers may prevail over the opposition at Yale and open a new era of purity in college athletics.

NOW that everybody is hard at work indoors, the fact has been very fully impressed on all that the University is fast outgrowing its quarters. Nowhere is this more evident than in the drawing rooms in Packer Hall. The rapid numerical increase of the last few years has filled these rooms to overflowing, crowding all the engineering departments, but especially the Civil and Mechanical. The time-honored expedient of reducing excessive numbers by "flunking them out" is no longer sufficient, and there must be an expansion somewhere. The new Physical Laboratory will do little to relieve this congestion, as the Electricals will probably continue to do their drawing under Civil and Mechanical Instructors.

The need for more space is patent to all; the question is, in what direction is this need most pressing? And this question is not hard to answer. Which of our departments has the smallest outfit in proportion to its needs and possibilities, and in comparison with other great Technical Schools? In which is there the least opportunity for work of that advanced and original character, facility for which constitutes the chief claim of any institution to the lofty, though much abused, title of University? We reply unhesitatingly, the Mechanical. The Massachusetts Institute of Technology, Cornell, Stevens, and many of the newer Western Colleges have large equipments for this class of work. We do not refer to shops, for the advantage of using them in a college course is an open question; but rather to the class of apparatus—steam and other motors, and facilities for work in thermo-dynamics and kindred branches of Physics—which make up a Mechanical Laboratory. Let the M. E. department be moved into a new building with large and well lighted drawing rooms, the necessary recitation rooms, and a good laboratory, and Packer Hall will be large enough to accommodate the growth of the C. E. and M. E. departments for a good many years to come.

No doubt those in authority feel this need even more keenly than we do; still it can not be amiss, or be considered impertinent, for every student to take an interest, and a strong interest, in the development of the University's facilities. The need for this improvement is great, and increases with the reputation which our high standard has gained. The old brick buildings, Christmas and Saucon Halls, will probably be vacant soon, and will be available to relieve the most pressing present needs; but they can serve only as a temporary expedient. This is clearly Lehigh's "next thing," and we are confident that, before many years have passed, there will be on our Campus a Mechanical Building that will equal our other buildings in beauty and utility, and enable Lehigh to rank in this respect, among the great Engineering Schools of the world.

FOR LEHIGH MEN.

This column will contain, chiefly, such information in regard to addresses and occupations of Alumni as does not appear in the latest issue of the *Lehigh Register*. Please contribute.

'74. C. W. Haines, C.E., for the present address 906 Filbert Street, Philadelphia, Pa.

'80. L. B. Treharne, B.A., with *New York Times*, New York City.

'83. F. J. Crilly, B.A., M.A., Special Deputy Collector of Customs, Philadelphia, Pa.

'84. D. G. Kerr, B.M., Superintendent of Furnaces, Edgar Thomson Steel Co., Braddock, Pa.

'86. J. H. Brown, C.E., in Engineering Department of Duluth, South Shore & Atlantic Railway, address P. O. Box 655, Marquette, Mich.

'87. R. S. Breinig, E.M., Engineering Department, Colorado Iron Works, address Gurney Hotel, Denver, Colorado.

'92. J. N. Bastress, C.E., with Cheny Chase Land Co., 1324 F Street, N. W., Washington, D. C.

'92. F. A. Coleman, C.E., with Stanwix Engineering Co., Rome, N. Y.

'92. F. W. Semper, A.C., Chemist, Antrim Iron Co., address Mancelona, Mich.

PERIODICAL AND BOOK NOTES.

KEY TO ABBREVIATIONS OF NAMES OF PERIODICALS.

TITLES.	WHERE PUBLISHED.	ABBREVIATIONS.
Abstract of the Proceedings of the Chemical Society.	London.	Ab. Proc. Chem. Soc.
American Architect.	Boston.	Am. Arch.
American Chemical Journal.	Baltimore.	Am. Chem. Jour.
American Journal of Mathematics.	Baltimore.	Am. Jour. Math.
American Journal of Pharmacy.	Philadelphia.	Am. Jour. Phar.
American Journal of Philology.	Baltimore.	Am. Jour. Phil.
American Journal of Science.	New Haven, Ct.	Am. Jour. Sci.
American Machinist.	New York.	Am. Mach.
American Manufacturer and Iron World.	Pittsburg.	Am. Man. and I. W.
Analyst.	London.	Anal.
Annals of Mathematics.	Charlottesville, Va.	Annals of Math.
Anthony's Photographic Bulletin.	New York.	Anth. Phot. Bul.
Astronomical Journal.	Boston.	Ast. Jour.
Atlantic Monthly.	Boston.	Atlantic
Blackwood's Edinburgh Magazine.	Edinburgh.	Blackwood's.
Bulletin of Iron and Steel Association.	Philadelphia.	Bull. I. and S. Ass.

Century Illustrated Magazine.	New York.	Cent
Chemical News.	London.	Chem. News.
Colliery Engineer.	Scranton, Pa.	Coll. Eng.
Electrical World.	New York.	Elec. World.
Electrician.	London.	Elec.
Engineering.	London.	Eng.
Engineering and Building Record.	New York.	Eng. Build. Rec.
Engineerimg and Mining Journal.	New York.	Eng. Min. Jour.
Engineering News.	New York.	Eng. News.
Harper's Monthly Magazine.	New York.	Harper's.
Iron.	London.	Iron.
Iron Age.	New York.	I. Age.
Journal of Analytical and Applied Chemistry.	Easton, Pa.	Jour. An. Ap. Chem.
Journal of Gas Lighting.	London.	Jour. Gas Light.
Journal of the Association of Engineering Societies.	Chicago.	Jour. Ass. Eng. Soc.
Journal of the Chemical Society.	London.	Jour. Chem. Soc.
Journal of the Franklin Institute.	Philadelphia.	Jour. Frank. Inst.
Journal of the Royal Microscopical Society.	London.	Jour. Roy. Micro. Soc.
Journal of the Society of Arts.	London.	Jour. Soc. Arts.
Journal of the Society of Chemical Industry.	London.	Jour. Soc. Chem. Ind
Lancet.	London.	Lancet.
Lehigh Quarterly.	South Bethlehem, Pa.	Lehigh Quar.
London, Edinburgh, and Dublin Philosophical Magazine.	London.	L. E. & D. Phil. Mag.
National Car and Locomotive Builder.	New York.	Nat. Car. Loc. Build
Photographic Times.	New York.	Phot. Times.
Popular Science Monthly.	New York.	Php. Sci. Mo.
Proceedings of the Engineers' Club of Philadelphia.	Philadelphia.	Proc. Eng. C. Phila.
Proceedings of the Royal Geographical Society.	London.	Proc. Roy. Geog. Soc.
Proceedings of the Royal Society.	London.	Proc. Roy. Soc.
Quarterly Review.	London.	Quar. Rev.
Railroad and Engineering Journal.	New York.	R. R. & Eng. Jour.
Railroad Gazette.	New York.	R. R. Gaz.

Science.	New York.	Science.
Scientific American.	New York.	Sci. Am.
Scientific American Supplement.	New York.	Sci. Am. Sup.
Scribner's Monthly Magazine.	New York.	Scribner's.
Transactions of the American Society of Civil Engineers.	New York.	Tr. Am. Civ. Eng.
Transactions of the Federated Institution of Mining Engineers.	London.	Tr. Fed. Min. Eng.
Westminster Review.	London.	West. Rev.

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Acoustic Purposes for Public Building. Am. Arch., Jan. 7.

Air Velocity in Pipes. Eng. News, Dec. 22.

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Alkaloids, Volumetric Determination of. Am. Jour. Pharm.

Aluminum, Use of in Buildings. Am. Arch., Dec. 3.

Aluminum and Uses. Am. Mach., Dec. 3.

Aluminum, Soldering and Polishing of. Am. Mach., Dec. 3.

Ampleochroic Acids. Am. Jour. Pharm., Dec.

*Amidol Developer. Phot. Times, Dec. 2.

Anthracite Coal, Production of, in 1892. Am. Man. and I. W., Jan. 20.

Anthracite Coal, Cost of. Coll. Eng., Jan.

Anthracite Coal, Waste in Mining and Preparation of. Coll. Eng., Jan.

Anthracite Coal Fields of Pennsylvania, Studies of the Stratification of the. Jour. Franklin Inst., Nov.

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*Arches, Three Hinged, Maximum Stresses from Moving Single Loads in the Members of. Jour. Frank. Inst., Nov.

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*Architects, Office Help for. Am. Arch., Nov. 19.

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*Bessemer Basic, at Pottstown. Iron. Nov. 4, '92. Eng. & Min. Jour., Nov.
Blasting Operations on Railroads. Eng., Jan. 13.
Blacksmithing, Practical Details of. Am. Mach., Dec. 1.
Blisters, Cause and Remedy of, in Silver Printing. Anthony's Phot. Bul., Jan. 14.
Boiler, Henshall Water Tube. Am. Mach., Dec. 8.
Boiler Tube Fastenings. Eng., Jan. 6.
Boron, Atomic Weight of. Ab. Proc. Chem. Soc., Nov. 29.
Boron, Amorphous. Am. Jour. Phar., Dec.
Brake Slack Adjustor. Nat. Car & Loc. Builder, Dec., '92.
Brake, Action of the Water. Nat. Car & Loc. Builder, Dec., '92.
Bridge, Hermon Lifting. R. R. & Eng. Jour., Jan.
*Bridge Designing, Some Disputed Points in R. R. R. R. Gaz., Nov.
Bridge, Fraser River. R. R. Gaz., Nov. 27.
*Bridge, Cincinnati and Newport Cantilever. Eng. Rec., Dec. 31.
Bridges, Brick, in Persia. Sci. Am. Sup., Dec. 3.
Bridge, Cantilever Highway. Eng. News, Dec. 8, '92.
Briquette Machine, Universal. Iron, Jan. 20.
Brooklyn, U. S. Armored Cruiser. I. Age, Jan. 5.
Bromine and Toluene, Studies on Interaction of. Ab. Proc. Chem. Soc., Nov. 29.
Building, Laws of Strength of. Am. Arch., Nov. 12.
Butter, Acid. Am. Jour. Phar., Nov.
Butter, Microscopical Examinations of Pure. Am. Jour. Phar., Dec.
Butter, Reichert Process for. Chem. News, Nov. 18.
*Bucrania. Am. Arch., Nov.
Butyric Acid, Distillation of. Analyst.
Butt Connections of Steel Plating of Large Vessels. Sci. Am., Dec. 3.

Cable, Low Capacity Telephone. Elec., Dec. 2.
*Cable, Submarine. Elec., Nov.
Caisson, Pneumatic. Eng. News, Nov. 29.
Calcium from Strontium, Quantitative Separation by Action Amyl Alcohol on Nitrates. Jour. An. Ap. Chem., Nov.

*Cam Rollers, Step Bearings of. Am. Mach., Dec.

Cam Rollers, Conical. Am. Mach., Jan. 12.

Camphoric Acids, Methylic Salts of. Ab. Proc. Chem. Soc., Nov. 29.

Camphor and Zinc Chloride or Sulphuric Acid, Interaction of. Ab. Proc. Chem. Soc., Dec. 6.

Cambrian Rocks of Penn. Am. Jour. Sci., Nov.

Canal Gauges. Eng. and R. R. Jour., Jan.

Canals, Suez and Nicaraugua. R. R. Gaz., Jan. 13.

Canal, Ship. Jour. Frank. Inst., Nov. '92.

*Capitols. Am. Arch., Oct. 29.

Carving Machine. Am. Arch., Nov. 5.

Carbonxyls, Metallic. Am. Jour. Sci., Nov.

Car Wheels, Chilled. Am. Mach., Dec. 15.

Car, Twin Hopper Gondola. Nat. Car and Loc. Build., Nov.

*Cast Iron, Keep's Test for. Am. Mach., Jan. 5.

Castings, Malleable Iron. Am. Mach., Jan. 12.

Casks of Iron. Am. Arch., Nov. 12.

Cast, Non-Uniformity of Iron made in one. Eng. and Min. Jour., Dec. 10.

Cast Iron Pipe Specifications. Eng. Rec., Jan. 28.

Cement, Portland, Manufacture of. LEHIGH QUARTERLY, Oct.

Cement Mortars, Investigations as to Effect of Retempering on. Eng. News, Jan. 5.

*Centrifugal Force as Applied to Revolving Machinery. Sci. Am. Sup., Jan. 25.

Champaign School of Architecture. Am. Arch., Dec. 23.

Chignecto Ship Canal. Eng. Rec., Jan. 7.

Chimney Construction. Eng. Rec., Jan. 14.

Chromium and Iron Alloy. I. Age, Nov. 4.

*Chromium Steels. I. Age, Nov. 18.

Chromium Cast Steel. I. Age, Dec. 2.

Chromium, Electrolytic Preparation of. Elec., Dec. 9.

Circuits, The Impediment of Branched. Elec., Jan. 13.

Citric and Aconitic Acids, Anhydo Derivations of. Ab. Proc. Chem. Soc., Nov. 29.

Coal Slack Remover. Am. Mach., Jan. 19.

Coal, Spontaneous Combustion of. Jour. Gas Light., Jan. 3.

Cogging Wheels. Am. Mach., Nov. 3.

Coke Ovens, Hoffman-Otis. Eng. and Min. Jour., Nov. 5.

Coke Ovens. Coll. Eng., Nov.

Coke, Waste of, in Manufacture. Coll. Eng., Jan. and Nov.

Coke Oven, Thomas' Patent. Eng. and Min. Jour., Nov. 26.

Coke Ovens, Recovery of By-Products from. Jour. Gas Light., Jan. 3.

*Color, Photography of. Am. Jour. Sci., Nov.

*Color Blindness. L. E. & D. Phil. Mag.

Collodion Plates for Transfers. Phot. Times, Jan. 20.

*Commutators, Sparking at. Elec., Dec. 9.

*Construction, French. Am. Arch., Dec. 17.

Conductors, Underground Copper. Elec., Nov. 4.

Conductor, Effect of Self-Induction and Distributed Static Capacity in a. Am. Jour. Sci., Nov.

Conductor, Earthing the Middle, of a Three-Wire System. Elec., Nov. 11.
Copper, Hardening of. Am. Arch., Dec. 17.
Copper, Resources of U. S. Jour. Soc. Arts, Dec. 2, and Iron, Dec. 9.
Copper, Tempered. Iron, Nov. 4.
Countershaft, A New Multiple Speed. Am. Mach., Feb. 2.
Cranes and Runways, World's Fair Travelling. Am. Mach., Feb. 2.
Crane, An Electric Travelling. Eng., Jan. 13.
Crusher, Gyratory Rock and Ore. I. Age, Jan. 5.
Crystal Drawing. LEHIGH QUARTERLY, Oct.
Curves, Transition. Eng., Jan. 13.
Curves, On Current. Proc. Roy. Soc., Nov.
Cylinder Condensation and Steam Engine Economy. R. R. and Eng. Jour., Jan.

*Dam, Construction of the Perigar. Eng. Rec., Dec. 31.
Dams, Flow of Water Over. Eng. News, Nov. 10.
*Dam, Austin. Eng. News, Jan. 12.
Dam, New Concrete Masonry of Butte City. Eng. News, Dec. 15.
Derrick, 125 T Floating. Eng. News, Jan. 5.
Desulphurization of Iron and Steel. Iron, Jan. 20. Eng. News, Nov. 14.
Desulphurization of Iron and Steel by Calcium Oxychloride Process. Iron, Dec. 3
*Development of Plates in a Vertical Position. Phot. Times, Nov. 18.
Developers, Comparison of. Phot. Times, Nov. 25.
Dicarboxyglutaconic Acid. Ab. Proc. Chem. Soc., Nov. 29.
Die Sinking, Practical Details of. Am. Mach., Dec. 29.
Discharges, Experiments with High Frequency Electrical. Elec.World, Jan. 28.
Docks, Bristol. Am. Arch., Nov. 12.
Draft, Forced, and Leaky Tubes in Marine Boilers. Eng., Jan. 6.
Drill, Rock, Applied to Opening the Tap Hole of a Blast Furnace. Am. Man. and Iron World, Jan. 20.
Drilling Machine, Small Portable. Am. Mach., Nov. 3.
Drill, Rock, and Air Compressor. Iron, Jan. 13.
Drainage Blunders. Eng. Rec., Dec. 10.
Drawbridge, N. & W. R. R. Eng. News, Nov. 3, '92.
Dump Car, Compressed Air. R. R. Gaz., Nov. 11.
Dyes, Note on. Chem. News, Nov. 18.
Dynamo, A High Frequency. Elec., Dec. 9.
Dynamo Design. Elec., Dec. 9.

*Earth, Measurement of the. Jour. Frank. Inst., Nov., '92.
Electricity at World's Fair. Elec. World, Jan. 7 and 28.
Electricity Building at Fair. Eng., Dec.
Electrical Resistances of Allotropic Silver. Am. Jour. Sci., Nov.
*Electricity and Ether. Elec. World, Jan. 28.
Electrolysis, Problems of Commercial. Elec., Nov. 25.
Electro-extensometer. Am. Mach., Dec. 29.
Electro-Magnetic Theory. Elec., Dec. 30.
Electric Distribution, Three Systems of. Elec. World, Dec. 3.

*Electrical Properties of Pure Substances. L. E. & D. Phil. Mag.
Elevator, Sprague Electric. R. R. Gaz., Dec. 2.
Elevated R. R. in Philadelphia. R. R. Gaz., Dec. 16. Eng. Rec., Jan. 28.
Emulsion Paper, Chemistry of. Anth. Phot. Bul., Jan. 14.
Emulsion Paper, Collodio Chloride. Phot. Times, Nov. 4, '92.
Engines, Quadruple Expansion Mill. Am. Mach., Dec. 29.
Engine, A Horizontal Compound, with Receiver. R.R. & Eng. Jour., Feb.
Engine, Petroleum. Eng., Dec. 2.
*Engineering Schools of United States. Eng. News, Nov.
Engine Traction, Design and Construction of. Eng. News, Dec. 1.
Ether, Use of, as a Medium in Skin Medication. Am. Jour. Phar., Dec.
Ethylene, Behavior of, With less than its own Volume of O on Explosives. Ab. Proc. Chem. Soc., Nov. 29.
Exhaust, Gas Engine. Elec., Nov. 25.
*Explosions, Boiler. Eng., Jan. 6 and 13.
Exposure, Time of, in Photography. Phot. Times, Nov. 4.
Exposure, On the Development of Instantaneous. Phot. Times, Nov. 4.
Explosions, Phenomena of Coal Dust. R.R. Gaz., Dec.

Fair, World's Fair Buildings. Am. Arch., Nov. 5, and Dec. 24.
Fair, World's Fair State Buildings. Am. Arch., Nov. 26.
Fan, Steel Fan with Engine. Am. Mach., Dec. 8.
Fault Rules. Coll. Eng., Nov.
Fermentation Industries, Chemistry of. Chem. News, Nov. 12.
Ferric Salts with Sulphocyanides, Reaction of. Chem. News, Jan. 20.
Ferro-Types. Phot. Times, Nov. 11.
Ferro-Silicon and Silicieous Spiegel, Analysis of. Chem. News, Jan. 20.
Ferro-Tungsten. Jour. Frank. Instit., Dec.
Ferro-Tungsten. Chem. News, Dec. 30.
*Ferrochrome, Aluminum, Tungsten, Titanium, Silicon, Analysis of. Chem. News Dec. 16.
Files, American versus Foreign. Sci. Am., Jan. 14.
Fire-Damp Detector. Jour. An. Ap. Chem., Nov.
Fire-Damp, Nature and Product of. Coll. Eng., Nov.
Flange-Wheels. Eng. News, Feb. 2.
*Fly-Wheels, A Study of. Am. Mach., Oct. 27.
*Fly-Wheel Formulas. Am. Mach., Dec. 15.
Fly-Wheels, Strength of. Eng., Jan. 13.
Fly Band Wheels, Strains in Rim of. Am. Mach., Dec. 8.
*Flying Machines, Progress in. R. R. and Eng. Jour.
Fluosulphonic Acids. Ab. Proc. Chem. Soc., Nov. 29.
Flush Tanks, Wheeler. Eng. Rec., Dec. 10.
Forge, Electric. Sci. Am. Sup., Jan. 10.
*Formates Metallics, Electrolysis of. Chem. News, Nov. 25.
Forgings, Selection and Treatment of Steel for. Iron, Jan. 20.
Foundry, Relation of Chemistry to. I. Age, Jan. 27.
Fountains. Am. Arch., Oct. 29.

Fountains Electric, Construction and Operation of. Elec. World., Jan. 21.
Fuels, Calorific Value of. Jour. Soc. Arts, Dec. 30.
Fuel, Relative Values of Clean and Dirty. Am. Man. and I. W., Jan 13.
Furnaces, Hawley Down Draught. I. Age, Jan. 12.
Furnaces, Orvis Down Draught. I. Age, Jan. 19.
Furnaces, Down Draught, for Steam Boilers. R. R. and Eng. Jour., Feb.
Furnaces, Marine Boiler. Eng., Jan. 20.

Galvanometer, Ballistic. Elec., Dec. 16.
Galvanometer, Deflection and Control of. Elec., Dec. 30.
Gas vs. Electricity for Illuminating Purposes. Elec., Jan. 20.
Gas Furnace, A High Temperature. Jour. Gas Light., Jan. 10.
*Gas of Coal, Manufacture and Consumption of. Jour. Gas Light., Jan. 10.
Gas Engine, Large. Sci. Am., Nov. 26.
Gases, Decomposition by Shock. Jour. Gas Light., Nov., '92.
Gas, Purification of. Jour. Gas Light., Nov. 15.
Gauge, Self-Closing Water. Am. Mach., Oct. 27.
Gauge, Pressure. Sci. Am., Dec. 17.
Gems, Manufacture of Artificial. Chem. News, Dec. 23.
Geology, Tertiary, of Maryland. Am. Jour. Sci., Dec.
Geology, Economic, of Minnesota. Coll. Eng., Jan.
Geology of Coal, Gas, Iron, Oils, etc. Coll. Eng., Jan.
Gearing, Friction. Am. Mach., Nov. 17.
Gear, a New Valve. Am. Mach., Dec. 29.
Glacial Epoch, Unity of. Am. Jour. Sci., Nov.
Glacial Pot Holes in California. Am. Jour. Sci., Nov.
Glassware, Manufacture of. Sci. Am. Sup., Nov. 19.
Gold Milling. Tr. Fed. Min. Eng.
Gold, Determination of, in Dilute Solution. Chem. News, Dec. 2.
Gold and Silver, Fire Refining of. Eng. & Min. Jour., Jan. 21.
Gold, Variations in the Milling of. Eng. & Min. Jour., Dec. 3.
*Gold Extraction, Cyanide Process for. Eng. & Min. Jour., Nov.
Gold and Tin Alloy, Formation of. Am. Jour. Sci., Nov.
Gordon Formula, Analytical Discussion of. Eng. News, Nov. 17.
Gossan, Chemistry of. Eng. & Min. Jour., Dec. 17.
Gun Barrel Drilling Machine. Am. Mach., Nov. 3.
Gun, Segmental Wire. Iron, Nov. 4. Eng. News, Nov. 24.
Gyration Radius of, for Hollow Cylindrical and Square Columns. Eng. News, Feb. 2.

Harmonics, Effect on Transmission of Power by Alternating Currents. Elec., Dec. 16.
Haulage, Underground. Tr. Fed. Min. Eng.
Headlight, Electric. R. R. Gaz., Nov. 4.
Heat, Transformation of, into Chemical Energy in Manufacture of Water Gas and Carbon Monoxide Gas. Iron, Dec. 9.

Heat Distribution in a Steam Engine. Eng., Nov. 25, '92.
Heat to Work, Conversion of. Am. Man. and I. W., Jan. 6.
Heat Generated per C. P. by Oils and Gas Lamps. Eng., Jan. 20, Jour. Gas Light., Jan. 30.
Horticultural Building. Eng., Nov.
Hydrophone. Sci. Am., Dec. 17.

Iron Bars, Tests of. I. Age, Jan. 19.
Iced Bar Base Apparatus of U. S. Coast and Geodetic Survey. Am. Jour. Sci., Jan.
Illumination, Distribution and Measurement of. Eng. News, Nov. 24.
Imidosulphonates. Ab. Proc. Chem. Soc., Nov. 29.
Incandescent Lamp, Life and Efficiency Tests of. Elec., Nov. 25.
Incandescent Lamp, Investigation of the Energy Consumed by. Elec., Dec. 23.
Incandescent Lamp, Preparation of Filaments for. Elec., Dec. 23.
Incrustations, Feed Water and Boiler. R. R. Gaz., Jan. 6.
Induction Coil, Experiments on. Elec., Jan. 20.
Indicator, Center. Am. Mach., Feb. 2.
Indicator, Straight Line. Am. Mach., Feb. 2.
Indicator Cards. Am. Mach., Nov. 10 and Dec. 22.
Inertia, Moment of, by a Graphical Method. LEHIGH QUARTERLY, Oct.
Injector, Double Tube. Am. Mach., Oct. 27.
*Inventive Faculty, Cultivation of, by Solution of Construction Problems. Am. Mach.
Iodine and Potassium Chlorate, Interaction of. Ab. Proc. Chem. Soc., Nov. 29.
Iodine Action of, on a mixture of Sulphite and Thio-Sulphite. Ab. Proc. Chem. Soc., Nov. 29.
Iodine, Bromine and Chlorine, Separation of. Jour. An. Ap. Chem., Nov.
Iodine, a Simple Method to Determine the Water of. Am. Jour. Phar., Nov.
Iodomercurates of Organic Bases. Am. Chem. Jour., Dec.
Iron and Steel, Passive State of. Iron, Jan. 13.
*Iron and Steel Analysis. Chem. News, Nov. 4.
Iron, Magnetic Properties of Pure. Proc. Roy. Soc., Nov.
Iron Manufacture, Waste Products of. Am. Man. and I. W., Jan. 27.
*Irrigation of India. R. R. and Eng. Jour., Jan.
*Irrigation of Egypt. Eng., Jan. 6.
Isogonal Transformation, Use of Supplementary Curves in. Am. Jour. Math., Dec.

*Jackets, Hot Air, for Steam Cylinders. Eng., Jan. 6.
Jackets, Steam. Eng., Jan. 20.
Jetties at Mouth of Brazos River, Texas. Sci. Am., Jan. 21.
Joints Expansion, Used in Memphis Bridge. Eng. News, Dec. 1.
Joints, Riveted. R. R. and Eng. Jour., Feb.

Kankakee Marsh, Drainage of the. Eng. News, Nov. 3.
Keys, Standard. Am. Mach., Dec. 22.
Key Turning Machine. Am. Mach., Dec. 22.

Ladle, Foundry. Am. Mach., Jan. 12.
Lamp, A New Separable. Elec. World, Jan. 28.
Lamp, New Swan-Edison. Elec., Nov. 11.
Lantern Slide in Photography. Anth. Phot. Bul., Jan. 14.
Lard, Analysis of Steam. Analyst.
*Laws, Municipal Building. Am. Arch., Dec. 10.
Lead Slags, Deselverization of. Eng. and Min. Jour., Feb. 4.
Lead Smelting, Slag Pots Used in. Eng. and Min. Jour., Dec. 31.
Lead, Volumetric Determination of. Jour. An. Ap. Chem., Nov.
Lead of Different Degrees of Purity, Action of Sulphuric and Nitric Acids on. Eng. and Min. Jour., Jan. 14.
Leather Dyeing. Sci. Am., Dec. 3.
Library, Carnegie Free, in Scotland. Am. Arch., Oct. 29.
*Light, Generation of, from Coal Gas. Jour. Gas Light., Nov. 29.
Lime, Determinated of, in Basic Slags. Analyst.
Link, Affecting Point of, Cut-off. Am. Mach., Jan. 19.
Liquid Fuels, Trials of. I. Age, Jan. 12.
Locomotives, Compound. Nat. Car and Loc. Build., Nov.
Locomotive, An Electric Mining. R. R. Gaz., Dec. 23.
*Locomotives, American and English. R. R. Eng. Jour., Jan.
Locomotive, Compound Double Bogie. R. R. Gaz., Dec. 30.
Locomotive, A Three-Cylinder. R. R. Gaz., Dec. 30.
*Locomotives, Comparative Tests of Simple and Compound. R. R. Gaz., Nov. 11.
Locomotive, Baldwin's Compound, for Fair. R. R. Gaz., Nov. 11.
Locomotive, Dean Compound. R. R. Gaz., Dec. 2.
Locomotive, Mineral Tank. Eng., Dec. 2.
Locomotive, Russian Compound. Nat. Car and Loc. Build., Nov.
Locomotive, Brooks Compound. Nat. Car and Loc. Build., Nov.
Locomotive Rogers. R. R. and Eng. Jour., Jan.
Locomotive Repairing. Nat. Car and Loc. Build., Dec.
Locomotive, Compound French. Eng., Jan. 20.
Lubrication. R. R. Gaz., Dec. 2.

Machinery Hall, Chicago. Am. Mach., Nov. 17.
Machinery Hall, Strains of. Eng. Rec., Dec. 24.
Magnetic Field, a Photographic Method to Map. Am. Jour. Sci., Nov.
Magnetic Effects of Sun on Earth. Am. Jour. Sci., Jan.
Magnets, Duplex. Elec. World, Jan. 21.
Magnesium, Electric Light. Elec. World, Jan. 7.
Magnesium Cell. Elec., Dec. 9.
Malic Acid, Separation of, from Citric, Succinic, Tartaric. Chem. News, Nov. 25.
Manganese in Ores, Technical Estimation of. Jour. An. Ap. Chem., Dec.
Manganese Ores in Mex. Tr. Fed. Min. Eng.
Manganese Steel. Iron, Nov. 4.
Map, Notes on the Construction of a Color. L. E. & D. Phil. Mag.
Marine Engines, Quadruple Expansion. R. R. Eng. Jour., Jan.
*Mesabai Iron Range. I. Age.

Methyline, Determination of Impurities in. Chem. News, Jan. 13.
Metal Mining. Coll. Eng., Jan.
*Metering Devices, Suggestions for. Elec. World, Jan. 14.
Mica, Electrical Uses of. Sci. Am. Sup., Jan. 28.
Mills Rolling, Details of Construction of. Eng. News, Nov. 10.
Mineral Oil, Flash Point and Heat of Burning. Am. Man. and I. W., Jan. 13.
Mining, Difficulty in. Coll. Eng., Nov.
Mining, Relative Efficiency of Electricity and Compressed Air in. Eng. and Min. Jour., Oct. 29.
Mining Operations, a Number of. Coll. Eng., Nov.
Mineries of Lake Huron. Iron, Nov. 25.
Mississippi River Improvement. Proc. Eng. C. Phila., Oct.
Molecular Weights, Modification of Beckman's Method to Determine. Ab. Proc. Chem. Soc., Nov. 29.
Mortar, Construction of Modern Breech Loading Rifled. Sci. Am. Sup., Jan. 7.
Motor, Tests of Ryan Special Series. Elec. World, Jan. 7.
*Motor, Calculation of a Small Electrical. Elec. World, Jan. 24.
Motor, Calculation of an Alternating Current. Elec. World, Jan. 21.
Motor, Without Counter E. M. F. Elec. World, Jan. 21.
Motors, Factory. Elec., Nov. 25.
Motor, Gas Motor Car. Sci. Am. Sup., Jan. 21.
Motor, An Ammonia R. R. R. R. Gaz., Feb. 3.

Napthalene, Some Homonucleal Tri-Derivatives of. Ab. Proc. Chem. Soc., Nov. 29.
Napthalene Manufacture. Eng. and Min. Jour., Jan. 14.
Negatives. Phot. Times, Dec. 9 and 18.
Nicaraugua Canal, Report on. Eng. News, Dec. 15.
*Niagara Falls Hydraulic Plant, Construction of. Eng., Dec. 23. Eng. Rec., Jan. 14.
Nickel and Copper Products of Can. Am. Arch., Dec. 24.
Nickel Steel in Machinery. Am. Mach., Dec. 8.
Nickel and Steel, Welding of. Am. Mach., Jan. 13.
Nickel for American Armor Plates. Bull. I. and S. Ass., Jan. 4.
Nickel Steel. I. Age, Jan. 19.
Nickel Analysis. Jour. An. Ap. Chem., Nov.
Nickel and its Uses. Pop. Sci. Mo., Dec.
Nitrous Oxide, Formation and Preparation of. Jour. Chem. Soc., Nov.
Nitric Acid, Action of, on Metals. Am. Jour. Phar., Dec.
Nitric Acid, Manufacture of. Eng. and Min. Jour., Jan. 28.
Nitrogen, Oxidation by Spark of O. Am. Jour. Sci., Nov.
Non-Halation Plates and Mixed Emulsions. Phot. Times, Dec. 16.
Nut-Tapping Machine. Am. Mach., Oct. 27.

Observatory, A New Naval, at Washington, D. C. Am. Arch., Nov. 19.
Ohms Law, A Necessary Modification of. L. E. & D. Phil. Mag.
Oil Gas, Manufacture of. Am. Man. and I. W., Jan. 20.
Ore and Coal Dressing, Analytical Results of. Iron, Jan. 13.

Orcinol and other Products from Dehydra-Acetic Acid. Ab. Proc. Chem. Soc., Dec. 13.

Oscillations, Experiments Determining Electrical. Elec. World, Jan. 7.

Oxides, Action of High Heat on. Elec., Dec. 23.

Oxalic Acid, Anhydrous. Ab. Proc. Chem. Soc., Dec. 13.

Packing Rings, Steam. Am. Mach., Nov. 10.

Panel Carving Machine. Am. Mach., Feb. 2.

Panama Canal, Projects to Complete. Sci. Am. Sup., Nov. 5.

Paper Testing. Sci. Am. Sup., Nov. 5.

Para Anthracene, Preparation and Constitution of. Am. Chem. Jour., Dec.

*Passenger Car, Standard of B. & O. R. R. Nat. Car. Loc. Build., Feb.

*Passenger Traffic in Great Cities. Eng. Rec., Jan. 14.

Pattern Work, Rubber. Am. Mach., Dec. 1.

Pavements, Cedar Block. Eng. Rec., Dec. 10.

Phosphoric Acid, Determination of, in Basic Slags. Jour. An. Ap. Chem., Nov.

*Phosphorous in Steel. R. R. and Eng. Jour., Jan.

Phospho-Molybdic Salt. I. Age, Jan. 27.

Phosphorus, Rapid Determination of, in Iron and Steel and Ores. Chem. News, Dec. 30.

Photography, Long Distance. Phot. Times, Nov. 4.

Photography to Physics, Application of. Phot. Times, Nov. 4.

Photography, Color. Phot. Times, Jan. 16.

Pig Iron, Product of U. S. in '92. Bull. I. and S. Ass., Jan. 18, and Am. Man. and I. W., Jan. 13.

Piles, Formulas for Bearing Weights. Am. Arch., Nov. 12.

*Pile Driving, Uniform Practice in. Eng. News, Nov. 3.

Piers, Bridge, in N. River. Eng. News, Feb. 2.

Piers, Bridge, Moved by Expansion and Contraction of Ice. Eng. News, Jan. 25.

Pin Hole Photography. Anth. Phot. Bul., Jan. 14.

Pipe Flanges, Standard. Eng., Jan. 6.

Pipe, Flexible Water, Laying of. Sci. Am., Nov. 12.

Pipe Computation. Eng. News, Dec. 22.

Piston, Adjustable Solid. Am. Mach., Dec. 22.

Plane Chuck. Am. Mach., Jan. 5.

Plate, Ultra-Violet Sensitive, and Photography of Light Rays. Anth. Phot. Bul., Jan. 28.

Plates, Multiple Coated. Phot. Times, Dec. 23.

Platinotype Process, Ferric Oxide and Chlorate of Iron Solution for, Anth. Phot. Bul., Jan. 28.

Potassium, Report on. Chem. News, Nov. 25.

*Power in Mining. Coll. Eng., Nov.

*Power from Central Stations, Development and Transmission of. Eng., Jan. 20.

Power, Electrical Transmission of, and its Analogies in Hydraulics. Tr. Fed. Min. Eng.

Printing Methods, Modern. Phot. Times, Jan. 16.

Projectile, a Multiple, or Compound Gun. Eng., Jan. 13.

Pumps at Fair. Am. Mach., Dec. 15, Jan. 19.
Pump Valves. Am. Mach., Jan. 12.
*Pump, Natural Governing of Direct Action Steam. Am. Mach., Jan. 26.
Punching Steel Plates, Effect of. Eng. Rec., Dec. 24.
Pyrometer, Le Chatelier, for Blast Furnaces. Iron, Nov. 18.

Quadrants, Close Notched. Nat. Car and Loc. Build., Nov.
Quinoline, Hydrozines of. Ab. Proc. Chem. Soc., Nov.
*Quinoline Salts, Color and Fluoescence of. Ab. Proc. Chem. Soc., Nov. 29.

Rack Railroad, Breiz and Rothhorn. Eng., Nov. 18.
Radiation, Experimental Comparison of, at Certain Temperatures. Am. Jour. Sci., December.
Radiation, Representation of Hertz Researches on Electrical. Elec., Dec. 30.
Rails, Expansion of Continuous. Iron, Dec. 2.
*Railroad, St. Gaul and Gais Mt. Eng., Nov.
Railroads of U. S., Electrical. Elec., Dec. 30.
Reading Combination from Miners' Standpoint. LEHIGH QUARTERLY, Oct.
Recarburization of Scrap Iron and Steel, Apparatus for. Am. Man. and I. W., Jan. 20.
Refuse, Disposal of. Eng. News, Dec.
Resins, Solution of Medicinal. Am. Jour. Phar., Dec.
Resistance Coil, Alloys for. Elec., Dec. 2.
*Resonator, Dissipation of Electrical Energy in Hertz. Elec., Nov. 18.
Reverberating Furnace, Lanth. Am. Man. and I. W., Jan. 20.
Rifles, Magazine, and Smokeless Powder. Sci. Am. Sup., Feb. 4.
Rifle Manufacture. R. R. and Eng. Jour., Feb.
Rifle, Mannlicher. R. R. and Eng. Jour., Jan.
Rolls, Failure of Chilled. Iron, Dec. 16.
Rolling Stock, English Electric. R. R. Gaz., Feb. 3.
Roll for Electrically Heated Bars. I. Age, Jan. 27.
Roofing, New German. Am. Arch., Nov. 12.
*Rope Driving, Notes on. Am. Mach., Nov. 10.
Rubber Goods, Analyses of. Analyst.
Rudder for Battleship Oregon. I. Age, Jan. 27.
Rust Prevention. I. Age, Jan. 12.

Safety Lamp in Coal Mining. Coll. Eng., Jan.
Sandal Wood and Cedar Oil, Note on. Am. Jour. Phar., Jan.
Sands and Shingles. Am. Arch., Nov. 5.
*Sandstone Quarries, Potsdam Red. Sci. Am., Jan.
Sanitation at Manchester. Am. Arch., Oct. 29.
Screw Propelling. Eng., Jan. 6.
Screw Machine, Turret. Am. Mach., Dec. 1.
Separator and Washer, New Coal. Coll. Eng., Jan.
Sewerage Purification in America. Eng. News, Nov. 3.
System of Sewerage, Wilmington, Del. Eng. Rec., Dec. 24.

Sewerage Works, Boston. Eng. Rec., Jan. 21.
Ships and Ship Building on Great Lakes. R.R. Gaz., Nov. 4.
Ships, Transmission and Distribution of Power in. Sci. Am. Sup., Dec. 17.
*Shutter, Speed and Efficiency of. Anth. Phot. Bul., Jan. 14.
Signal, Automatic Block. R.R. Gaz., Jan. 13.
Silicates, Determination of the Alkalies in. Jour. An. Ap. Chem., Dec.
*Silver Hemisulphate. Phot. Times, Jan. 20.
Silk, Nitrated. Am. Jour. Phar., Nov.
*Smoke, Prevention of. Coll. Eng., Nov.
Sizing of Paper. Phot. Times, Nov. 25.
Snow on Railroads. Eng. News, Dec. 29.
Soda Bisulphite, Uses and Valuation. Sci. Am. Sup., Dec. 3.
Soaps, Determination of Water and Fatty Matter in. Jour. An. Ap. Chem., Nov.
Soap Manufacture with Cotton Seed Oil. Sci. Am. Sup., Nov. 12.
Spectra of Alkali Metals, Infra Red. Am. Jour. Sci., Jan.
Spectra of Easy Volatile Elements and Salts, and Separating from Alkaline Earths, Ab. Proc. Chem. Soc., Dec. 6.
Station, P. & R. R. R. Terminal at Philadelphia. Eng. News, Feb. 2.
Steam Pipe System at Fair. Am. Mach., Dec. 22.
*Steam Power Plants. Eng. Rec., Dec. 3.
Steam Cylinders and Liners, Large. I. Age, Jan. 5.
Steam Heating of Cars. Sci. Am., Nov. 5.
*Steel, Chemical and Physical Properties. *Eng. Rec., Dec. 17. *I. Age, Jan. 5.
Steel Pipe Specifications. Eng. Rec., Dec. 24.
Steel and Iron, Substitution for Timber in Mines. Iron, Jan. 20.
Stones, Lamination in. Am. Arch., Nov. 26.
*Stoves, Hugh Kennedy Hot Blast. I. Age, Jan. 27.
Sugar, Researches on Agave Americana. Am. Chem. Jour., Nov.
Sugar Group. Am. Jour. Phar., Jan. Chem. News, Nov. 18.
Sulphuric Acid, Concentration in Glass Vessels. Jour. An. Ap. Chem., Nov.
Sulphuric Acid, Manufactured from Brimstone and Pyrites. Jour. An. Ap. Chem., December.
Sulphur Iodides. Am. Jour. Phar., Nov.
Sun, Photograph of the. Chem. News, Jan. 6.
Sunspot Observations. Astronom. Jour.
Supply, Method of Charging for a. Elec., Jan. 6.
Surveying, Mining. Coll. Eng., Jan. 6.
Surveying, Photographic. Phot. Times, Jan. 27.
Switches, Sub-Station Transformer. Elec., Jan. 6.
Sweeping Scows. Eng. Rec., Jan. 7.

Taper Boring Attachment. Am. Mach., Dec. 22.
Taper Rolling Machine. Am. Mach., Oct. 27.
Tar, Lignite. Am. Jour. Phar., Nov.
Technical Education, Advantages of a. Coll. Eng., Dec.
Technical Education, Use and Abuse of a. Am. Mach., Dec. 1.
Telephoning, Single Wire non-Insulated. Eng., Nov. 12.

Telephone, A New. Elec. World, Jan. 21.
Telephone, Long Distance. Elec. Eng., Dec. 14.
Telegraphy, Use of Shunt with High Self-Induction in. Elec., Jan. 6.
*Telescope, A New Five Foot Equatorial. Eng., Nov. 18.
Thermometers, Errors from Use of. Eng. News, Jan. 5.
Tides, Yearly. Proc. Eng. C. Phila., Oct.
Tie, Kinnear Metal. Eng. News, Dec. 1.
Ties, Tests of Metallic Railroad. R. R. and Eng. Jour., Jan.
Timber, Bending Tests in. Nat. Car and Loc. Build., Nov.
Tin Mines, Harney Peak. Eng. and Min. Jour., Nov. 26.
Tin Slags, Decomposition of, by Hydrofluoric Acid. Chem. News, Jan. 6.
*Tin Plate Machinery. I. Age, Jan. 5.
Tin Manufacture, American. Eng. News, Nov. 24.
Torpedo Boats, Strength of. Eng., Jan. 20.
Torpedo Boats. Sci. Am., Nov. 19.
Traction, Storage Battery. R. R. Gaz., Dec. 30.
Traction, Wynne System, Electric. Elec., Dec. 2.
Track Maintenance with Metallic Ties. R. R. Gaz., Jan. 20.
Track Tanks. R. R. Gaz., Dec. 16.
*Transit, Rapid Underground, N. Y. Eng. Rec., Dec. 3.
Transfer Table for World's Fair. Nat. Car and Loc. Build., Jan.
Transportation Building, Chicago. Eng., Dec. 2, and Eng. News, Dec. 29.
Transition Curves, Location of. Eng. News, Dec. 29.
Transformers, High vs. Low Frequency in. Elec. World, Jan. 7.
*Transformers, Experimental Researches on Alternate Current. Elec. World, Jan. 7.
Transformer, Diamond. Elec. World, Jan. 21.
Transformers, Open and Closed Magnetic Circuit. Elec., Nov. 25.
Transformer, Efficiency and Distribution of. Elec., Dec. 16.
Transmitter, Solid Back Long Distance Telephone. Elec., Dec. 2.
Trestle Construction. R. R. Gaz., Jan. 27.
Triphase System. Elec. World, Jan. 21.
Tunnel, Baltimore Belt Line. Am. Arch., Dec. 3.
Turbine, a Condensing Steam. R. R. Gaz., Dec. 2.
Turbine Water Wheel. I. Age, Jan. 27.
Turbines, Recent Development in. Eng. News, Jan. 12.

Umbria's Shaft, Repair of the. Eng. Rec., Jan. 7.

Vapors, Measuring the Vapor Pressures of Solutions. Ab. Proc. Chem. Soc., Nov. 29.
Vegetable Products, Crystallized. Am. Chem. Jour., Dec.
*Ventilating Shaft, Molding a Four Chamber. Am. Mach., Feb. 2.
Ventilation, Mine. Coll. Eng., Nov.
Ventilation and Heating. Eng. Rec., Dec. 10 and Jan. 28.
Viaduct and Drawbridge in N. Y. R. R. Gaz., Jan. 13.
Viaduct, Pecos River. Eng. News, Jan. 5.

Water Gas, Loss in Manufacture of. Am. Man. and I. W., Jan. 13.
Water Works, Intake of Milwaukee. Eng. Rec., Dec. 24.
Water, Deep, Channels, on Lake Levels. R. R. Gaz., Jan. 13.
Wattmeter, A Differential, for Alternating Currents. Elec. Eng., Jan. 13.
Weirs, Recent Experiments on Flow of Water over. Proc. Eng. C. of Phil., Oct.
Welding, Electric. Eng. News, Nov. 10.
Westinghouse Air Brake Improvement. Nat. Car and Loc. Build., Feb.
Westinghouse versus N. Y. Brake. R. R. Gaz., Feb. 3.
West Virginia Coal Fields, Development of. Coll. Eng., Dec.
Wheel Flanges. R. R. Gaz., Feb. 3.
Wind Bracing in High Buildings. Eng. Rec., Dec. 31.
Wine, Detection of Higher Alcohols in Spirits of. Am. Jour. Phar., Dec.
Wire System of Electric Distribution. Eng., Jan. 20.
Wood, Destructive Distillation of. Jour. Soc. Chem. Ind., Nov.
Worthington Sectional Water-Tube Boiler. R. R. Gaz., Dec. 9.

Yeast, Hydrolytic Functions of. Ab. Proc. Chem. Soc., Nov. 29.

*Zinc, Technical Determination of. Chem. News, Jan. 6.
Zinc, Volumetric Estimation of. Jour. An. Ap. Chem., Dec.

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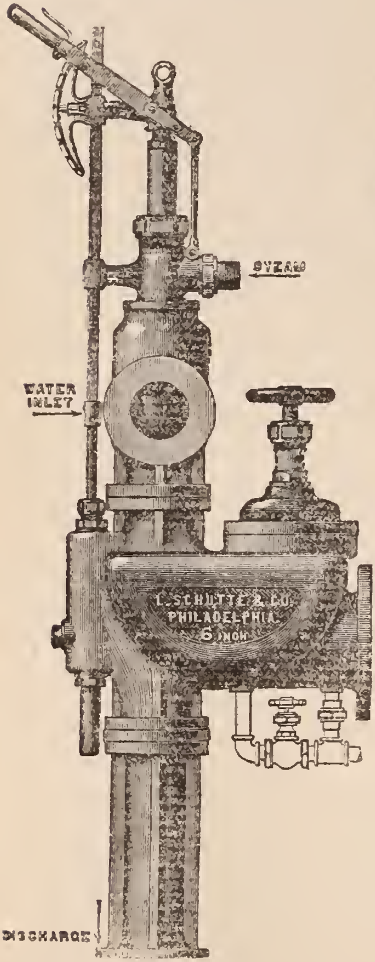

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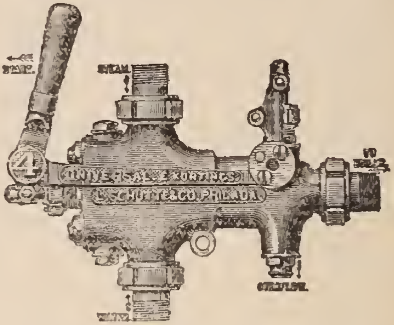

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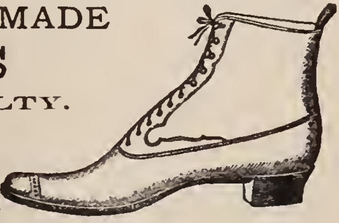

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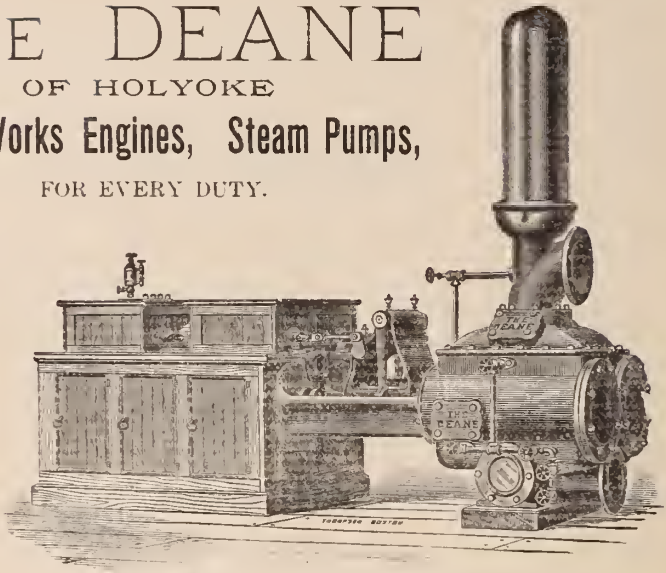

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